



Phoned me 12/1/93:
Deficiencies:
1. Math. & slug test data
2. Cross sec.
3. Demon. for no-migration.
R.W. Gillespie & Assoc.
P.O. 1730
Sanford, ME 04073

08 November 1993

Mister M Disposal, Inc.
Attn: Marvin and Sandra Mintyala
HCR 85 Box 4066
Lewistown, MT 59457

RECEIVED

NOV 15 1993

Subject: Geohydrologic Characterization
Mister M Landfill
Lewistown, Montana

MONTANA DEPARTMENT OF HEALTH
AND ENVIRONMENTAL SCIENCES

Dear Mr. & Mrs. Mintyala:

In accordance with your request Abenaki Geoenvironmental, Inc., (AGI) has conducted a geohydrologic characterization of the above referenced site. The work has been performed in general accordance with the work plan approved by Montana Dept. of Health and Environmental Sciences in their letter of 14 June 1993.

Briefly, the landfill site is composed of weathered shale followed by shales, siltstones, silty sandstones, and bentonitic seams of the Kootenai Formation. Thickness is greater than 300 feet based on data gathered during this study. Ground water is not present in the near surface formations. Since ground water is not present, a no migration petition is presented for the State's consideration. Typically, a ground water monitoring and sampling plan is also presented at this time. In lieu of that, we have developed a program for observing the existing wells to provide assurances that the no migration petition is valid over the life of the landfill.

We have enjoyed serving you on this project and look forward to a continuing relationship. If you have any questions or if we may be of further service, please contact us.

Very truly yours,
ABENAKI GEOENVIRONMENTAL, INC.

DRAFT
Robert W. Gillespie, P.E.

RWG:mah
cc: Patricia Potts (DHES)

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	LEWISTOWN, MONTANA	

NOVEMBER 1993

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EXECUTIVE SUMMARY

The Mister M landfill, located in the southwest quarter of Section 8, Township 15N, Range 19E east of Lewistown, Montana, has been in operation as a commercial landfill since *circa* 1958. It receives primarily residential or household waste including white goods. Woody debris, demolition debris, and metals are also accepted at the facility although the operators review loads of those materials before accepting them for disposal.

The landfill is constructed in a coulee which extended from the crest of a north-south trending ridge southwestward toward Hwy. 200. Based on older aerial photographs, filling began near the middle of the coulee and progressed both up and downhill. Prior to commencement of filling, the area was grassland and did not show signs of ground water discharge such as springs or long, sinuous areas of lush vegetation. Landfill cover consists of on site soils which are placed and compacted daily. The open or working face rarely exceeds one-half acre.

Geology of the site is dominated by Cretaceous age sediments of the Kootenai Formation, abutted by Falls River sandstones to the north and west. Kootenai sediments include shales and claystones with minor sandstone beds and one bentonite bed. The shales have weathered to a moderately plastic silty clay for depths of 5 to as much as 20 feet. Flex wall permeability tests on undisturbed shelby tube samples show permeability is on the order of 1×10^{-7} cm/sec. Slug tests performed in certain monitoring wells provide the same order of magnitude. Atterberg limits tests provide additional correlation. Briefly, the landfill is situated on weathered clay shale which acts as a liner much the same as a currently designed landfill would. Overall shale thickness is greater than 250 feet in the area. The aforementioned bentonite bed is included in the shale underlying the disposal mass. The Kootenai Formation continues to the south where it is overlain with colluvium and alluvium of Boyd Creek. Driller's logs from the valley floor show about 5 feet of silty clay (colluvium) underlain by 5 to 20 feet of gravel-sand mixtures, which are, in turn, underlain by shales of the Kootenai Formation.

Ground water is not present in the shallow rock at the site. Water well logs for the area show that first ground water is encountered in a sandstone unit at depths of 200 to 350 feet. The potentiometric surface for this aquifer is 25 to 100 feet below ground surface. Monitoring wells drilled for this project did not encounter groundwater except for one moist to wet zone in MW-2 located adjacent to, and downgradient of, the storm water detention pond. Surface water hydrology indicates that precipitation is used up by evapotranspiration, soil uptake, and runoff. Only negligible amounts can be shown to be available for ground water recharge in the vicinity of the landfill drainage basin.

Surface water hydrology shows that the existing pond functions as a detention basin for storms up to and including the 10 year event. This matches past history as presented to us by the owners. Additional pond capacity is necessary to provide adequate treatment under current regulations, and design will be provided under separate cover in the near future.

Methane monitoring wells were installed at two locations close to the downgradient edge of the landfill. Initial readings show that oxygen levels are within normal ranges and methane was undetectable. A methane monitoring plan is being developed for regulatory compliance.

Based on the investigations and engineering analyses we conclude that ground water is not present in measurable quantities within the basin containing the landfill. Hydrologic evaluations support this conclusion from the water balance standpoint. Migration of contaminants via ground water is unlikely and would, based on *in situ* and laboratory permeability measurements, take in excess of 200 years to reach Hwy 200 or the sandstone aquifer at depth. Therefore, the owner submits the landfill as a no migration petition under Section 16.14.714 of Subchapter 7.

1.0 INTRODUCTION

Need to discuss domestic well depths confining ggy shale (B&D sheet) w/ ml @ site ? Cross Sections

1.1 Purpose and Scope

The purpose of the study was to characterize the Mister M landfill site with respect to geohydrology and engineering aspects directly influenced by it. The regulations promulgated in Subchapter 7 have been utilized and followed to the extent practical during the course of our work.

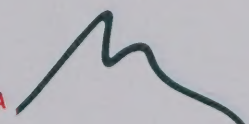
ARM 16.14

The regulations contained in Subchapter 7 require that the site be characterized with respect to disposal, surficial geology, geohydrology, and hazards. Potential problems relating to the operation and/or siting of the landfill must be identified; development of migration techniques is expected. Situations involving hazardous wastes or substances must be identified and corrected in a timely fashion. The subsequent sections follow the general outline presented in Sections 16.14.703, 704, 705, and 706 of Subchapter 7.

*ARM
Where is no migration?*

The scope of work as performed for the study was as follows:

1. review available low and high altitude aerial photography for the purpose of fault trace and lineament analysis.
2. develop a site plan using the aerial photography and USGS quadrangle maps as bases. The plan is at a scale of approximately 1"=100'.
3. conduct reconnaissance surficial and bedrock mapping of the site proper and the surrounding area for a distance of at least 1,500 feet, and display the data on the aforementioned base plan. Emphasis was placed on structure, stratigraphy, morphology, and potential aquifer recharge zones. The low level photographs were used for correlative purposes.
4. evaluate all acquired field and office data to determine relationships between topography, structure, and morphology as they relate to the geohydrologic regime. Emphasis was placed on the influences exerted by the landfill and its continued operation. Locations for subsurface explorations were selected during this task.
5. excavate, log, and sample 18 test pits at locations generally conforming to the anticipated perimeter of the landfill. The pits were logged and sampled by our geotechnical engineer in general accordance with ASTM and USCS recommendations. Representative soil samples were preserved in clean 1 liter glass jars for transport to



our geotechnical laboratory. The pits were logged continuously for lithology, structure, and evidence of ground water.

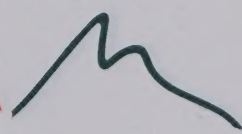
6. drill, log, and sample **7 monitoring wells** at the locations shown on Figure 2. The borings were drilled with hollow stem augers, and air rotary techniques. Cuttings were collected at frequent intervals at the discharge orifice and examined by our geotechnical engineer for soil or rock type and evidence of ground water. Standard penetration resistance (**split spoon**) samples were taken at 5 foot intervals or the engineer's discretion. **Undisturbed Shelby Tube** samples were obtained for laboratory permeability testing. All samples were scanned for volatile organic compounds using an **Hnu HW-101 photoionization detector**. The rig and its tools were cleaned prior to entering the site using steam cleaning and appropriate soap and water rinses. Similar cleanings were accomplished between each boring. In addition to Hnu screening, the bores were checked for **methane using an O₂/LEL meter** on a frequent basis. decon of rig + equipment

7. establish monitoring wells in each bore to allow for ground water sampling and level measurements. No monitoring wells penetrated the **deep, sandstone aquifer** which supplies water to the surrounding area. **MW-5 and 6** were drilled to depths which match or are below the more shallow downgradient wells. Conferences with DHES staff were utilized to determine depth and location in order to minimize future risks and liability. ?

The wells were constructed in general accordance with DHES and **NWWA** requirements. Elevations of ground surface, top of casing, and top of well were determined by level survey tied to NGVD datum. Well development was not necessary since ground water was not encountered. G
DHES forms

8. purge and sample all wells in accordance with EPA and NWWA protocols to obtain a baseline sample suite from which to design the future sampling and analysis program. Sterile disposable bailers were used which obviates the need for a rinsate blank sample. Preservation and filtration were in accordance with the same protocols unless field conditions dictated that other protocols are more appropriate. Although ground water was not encountered, slug tests were performed in MW-1, 2, 4, and 8. Following slug test completion these wells were bailed over the course of approximately 2 weeks as the test waters returned to the sand pack. Recovery was always lower with each development so we elected to sample and test what little water remained. if no water, ↑
slug test after

9. sample **surface runoff** from the landfill using grab or composite methods.
10. conduct analytical tests on the recovered water samples for the parameters listed in Table 1 of ARM 16.14.706 unless field observations and measurements suggest otherwise.
11. conduct index and physical property tests on selected soil and rock samples. Tests included **grain size distribution**, **Atterberg limits**, **water content**, and **dry density**. Emphasis was placed on grain size distribution because of its usefulness in estimating permeability, and undisturbed permeability using ASTM D5084 methodology.
12. conduct **in situ permeability tests** in each MW-1, 2, 4, and 8 using the slug test method since sufficient water was not available for a drawdown test.
13. evaluate all acquired field, office, and laboratory data with respect to the landfill and its influence on the environment, with emphasis on the geohydrologic regime. More specifically, we addressed:
 - local hydrology in and around the landfill. TR20 and 55 methodology in the form of **Hydrocad** was used. **TR20 and 55 are USDA Soil Conservation Service methods for evaluating runoff based on soil type, vegetation, slope, and precipitation.** *
 - local and regional geohydrology including bedrock and surficial or near surface aquifers. To the extent possible, recharge zones would be defined and a **water balance** would be calculated. Values of transmissivity, hydraulic conductivity, gradient, porosity, and storativity are discussed within the limitations of the data. (See No grid art)
 - influences of the landfill on surface and ground water flows. Lateral and vertical extensions of the landfill will be included in the evaluations.
14. design a **ground water monitoring plan** which will provide the basis for **continual evaluation of landfill impacts**, if any, on the ground water system(s). The plan would include sampling frequency, changes in standard protocol for sampling if needed, analytic parameters, and recommended evaluation methods using appropriate statistical or probabilistic techniques. Formal ground water models such as MODFLOW or MOC do not appear necessary at this writing.



15. provide deliverables which include but are not necessarily limited to:

- base site plan at 1"=100'.
- surficial and bedrock maps at the same scale as the base map.
- logs and monitoring well construction data using Unified Soil Classification System and ASTM descriptor methods.
- an engineering report describing our findings, conclusions, and recommendations. The latter could include additional ground water monitoring or surface water sampling locations.
- a ground water sampling plan which would encompass frequency, parameters, and data evaluation techniques. The plan will include the formalities of a Sampling and Analysis Plan or SAP.

1.2 History and Background

The landfill is located on the north side of Hwy. 200 approximately 3 miles east of Lewistown, Montana; a locus map is provide on Figure 1 attached. The 49 acre parcel is composed of the 30 acre licensed landfill site and an adjacent 19 acre parcel which is not included in the study. The site has been operated as a landfill since 1956 when Les and Vic Hartford owned the land and Don Harvey was responsible for landfill operation. Marvin and Sandra Mintyala purchased the land in 1974 but allowed others to operate the landfill until 1976 when they took over its management and operation.

1993
1956
37 yrs

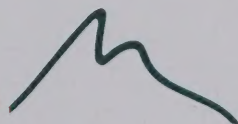
The waste stream appears to be primarily domestic materials with a high concentration of paper and plastics. Metals are limited to food cans and similar containers while glass was not observed in any quantity. Aluminum cans are scarce in the waste stream due to the price of recycled aluminum. Woody debris and brush appear to be seasonal and at a maximum in the spring and early fall. White goods, and ferrous and non-ferrous metals are accepted and stockpiled for transfer to scrap dealers and other appropriate facilities. White goods are baled approximately twice per year. Automobiles are not accepted at the facility any longer. Those which presently reside there are, for the most part, vehicles which were transported to the site by law enforcement authorities for storage. This practice ceased some years ago but the vehicles have never been claimed.

household refuse

compost?

sucked first?

Record reviews show that no monitoring or other environmental observations have been conducted on a regular basis at the facility. Several spot checks by DHES personnel are on file but contain only limited information. The landfill accepts asbestos and asbestos containing materials on a limited basis according to information provided by the owners and that gleaned from DHES files. On 29 October 1993 Mister M was cited for violation of 40



CFR part 61, Subpart M which deals with record keeping. Discussions with the Occupational Health Bureau indicate that the landfill is about 2 years behind in providing the required documentation. Efforts are being made at this time to bring the system into compliance. Data provided by the owners indicate the amount of asbestos material is small and delivered on an infrequent basis.

The site characterization which is required by regulation has been requested by DHES Solid and Hazardous Waste Bureau to bring the Mister M landfill into compliance with existing statutes. The characterization assumes that the facility will remain a disposal facility for household and domestic wastes. Special and/or hazardous wastes are specifically excluded from the site unless the proper investigations, designs, and construction techniques are implemented.

1.3 Acknowledgements

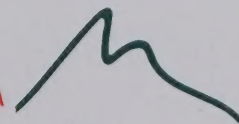
AGI wishes to thank Ms. Pat Potts of DHES for her patience and timely input during the field portion of this study. The lack of ground water made selection of boring locations tenuous and her attention to our needs is greatly appreciated. We also wish to thank A&E Drilling of Lewistown and Vidic Drilling of Roundup for their services and help in establishing monitoring wells in difficult circumstances.

2.0 INVESTIGATIONS

2.1 Literature, File, and Aerial Photograph Review

In order to develop a sense of site knowledge we reviewed available information including published geologic reports, geotechnical investigations in our files, DHES files, and old aerial photographs at the USDA Soil Conservation Service office in Lewistown, Montana. Published reports included those dealing with geohydrology, surficial and bedrock geology, structural geology, and ground water quality. A 1979 report by Hydrometrics, Inc., of Helena was reviewed for information pertinent to our study, as were several geotechnical investigations performed by the writer in the Lewistown area.

Aerial photography was limited to black and white positive but not in stereo pairs. Photographs dating to the early 1950's were available for review, and continued to the late 1980's. A new aerial photograph was flown at a scale of 1" = 100' to provide base maps upon which to develop geology and site characteristics. The photograph was also prepared in a negative for use in reproducing the plans.



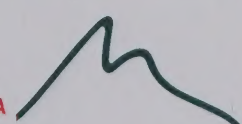
2.2 Site Work

Site investigations included field mapping of surficial and bedrock geology, confirmation of published data, installation of monitoring wells, undisturbed sampling of near surface soils, excavation of test pits, field permeability tests, sampling of surface water and detention pond sediment, and observation of waste streams into the landfill. Field mapping concentrated on correlating observed conditions with those presented in the geologic publications. Special attention was given to structural features near the site and to potential recharge zones for those formations known to be near the site. Features of importance include the Warm Spring Syncline, the Lewistown Bench Dome, and the benches which parallel Hwy 200. The drainage to the north of the site which ponds at Ruby Gulch Road was walked extensively for information on potential recharge areas. Our geotechnical engineer also used the field time to correlate geology as mapped by the various authors of reports on the general area. As will be discussed in later sections, some variations are apparent. Boring, monitoring well, and test pit locations were selected during this phase of the work.

Eight borings were drilled and seven monitoring wells were installed during the field program. Locations are shown on Figure 2, and logs are presented in Appendix A. MW-1,2,3,4, and 8 were drilled with a truck mounted hollow stem auger drill and standard penetration equipment. MW-5,6, and 7 were drilled with a Mayhew 1000 air rotary rig using a 6 5/8 inch drag bit. Standard penetration resistance tests were performed in general accordance with applicable ASTM standards, and field logs were developed using the criteria of the Unified Soil Classification System.

After drilling the borings which contain MW-1 and 2, it became apparent that a shallow ground water system was not present. Conversations with DHES staff were held to determine revised locations and the depths to which they should penetrate to avoid contacting the underlying sandstone aquifer. It was concluded that the original locations would be suitable provided that MW-5 and 6 were drilled to depths equal to or greater than those of the shallow wells. Additionally, shelly tube samples of the surface and near surface soils would be obtained for laboratory permeability testing.

The remainder of the borings were drilled following this conversation and monitoring wells were established in all but MW-3. Soil samples from the standard penetration sampler and auger/rotary cuttings were collected and preserved for use in laboratory classification and testing. All samples and the mouth of the boring were scanned with an Hnu photoionization detector for the presence of volatile organic compounds using the jar headspace method.



Many portable volatile organic analyzers detect the presence of a variety of gaseous compounds using the principle of photoionization. When a gas is exposed to ultraviolet light that possesses a higher energy level than its own ionization potential, gas molecules release positively charged ions. The higher the concentration of the gas within the sample collected by a photoionizer the greater the amount of released positive ions. Within the photoionization chamber of the instrument, the electric current created through photoionization is amplified and displayed on an analog or digital meter. The strength of the signal displayed on the meter relatively correlates to the concentration of photoionizable gases within the sample. It should be noted that actual concentrations of various compounds can only be determined through more rigorous analytic testing procedures.

AGI uses Hnu's Model HW-101 photoionization analyzer with a 10.2 eV ultraviolet lamp. Included within the spectrum of detectable gases include the volatile BTEX components of petroleum products (benzene, toluene, ethyl benzene, and xylene) and volatile compounds of commonly used solvents and degreasers (acetone, trichloroethene, tetrachlorethene, methyl ethyl ketone, etc.). Common naturally occurring gases such as oxygen and carbon dioxide possess ionization potentials above 10.2 eV; therefore, their presence is undetectable with this particular analyzer. The instrument is calibrated at the beginning of work at each site and is recalibrated after 4 hours of continuous use. Soil samples screened for the presence of petroleum hydrocarbons or other volatile organic compounds are collected in either clean 16 ounce glass jars or 1 quart ziplock polyethylene bags. For jars, an approximate 250 gram soil sample is placed into the jar which is then covered with heavy-duty aluminum foil and closed tightly with a screw-type lid. After placement into the jar, the sample is shaken for at least 30 seconds and then adjusted to a temperature range of 15° C to 25° C. For poly bags, the procedure is similar, but the bag is closed with sufficient air left in the bag so that the instrument can withdraw a sufficient sample. After a 15 minute (minimum) to a 120 minute (maximum) holding time, to allow the sample and headspace to equilibrate, the sample is shaken again before sampling. To sample jar headspace, the probe of a photoionizer is inserted through the foil covering. For poly bags the top of the bag is gathered and a photoionizer probe is inserted through the top of the bag, which is tightened around the probe. The highest steady reading is recorded as parts per million (ppm) benzene. PID readings are summarized in Table I.

Monitoring wells were also scanned for the presence of methane using a Gastech LF monitor. The wells were capped for at least 24 hours prior to scanning. Since the final valves were not in place on the 4 inch diameter wells which will serve as methane monitoring points, the probe was inserted under the cap to sample the trapped atmosphere.

Permeability tests were conducted in MW-1,2,4, and 8 using the falling head method. We had originally intended to perform recovery tests but the absence of ground water precluded that methodology. The wells were filled with water from the City of Lewistown to minimize bias in future sampling of the wells. The drop with time was measured and

recorded, and the procedure was repeated until two sets of readings produced approximately the same results. Head drops were measured to the closest 0.01 feet using an electronic depth gauge. Preliminary calculations were made in the field using the methods of Cedegren (1968). ?

How if zone is saturated/
infiltrated first test?

Shelby tube samples of the surface and near soils were obtained from various locations within the confines of the site; locations are shown on Figure 2. The samples were collected by hydraulically pressing a 3 inch Shelby tube into the soil after removal of the topsoil (if present). The tubes were sealed with plastic caps and dipped in wax to prevent moisture loss and help stabilize the sample for transport.

Subchapter 7 requires a minimum number of test pits and other subsurface exploration points based on the areal extent of the landfill. As presented in the work plan, eighteen test pits were excavated at the locations shown on Figure 2. The excavations were made with a Drott backhoe mounted on a 5 ton 4x4 truck and were carried to refusal on bedrock in all cases. Our geotechnical engineer logged the pits for soil or rock type, lithology, moisture content, and evidence of ground water, and developed field logs in accordance with USCS procedures. where are these... App?

Nash Surveying of Lewistown located all test pits and monitoring wells by instrument survey using a property pin for a beginning and an NGVD datum. The survey results were transferred to AUTOCAD where the scale was adjusted to match that of the aerial base. An underlay was made on the plotter to allow pen transfer of the locations to the aerial base. Locations and elevations should be considered accurate only to the degree implied by the methodology.

Although ground water was not present during drilling or before field permeability tests were made, we elected to bail the water remaining in each well and obtain a sample for analytical testing. The wells were bailed on a daily basis until recovery was virtually nonexistent. It is important to note that any recovery was only water draining from the sand pack and soil immediately adjacent to the borehole wall. The samples were obtained with sterile bailers and preserved in a manner consistent with DHES and NWWA protocols. Subsequent measurements have shown that the remaining water levels are slowly dropping although evaporation into the atmosphere each time the wells are opened is the most likely source of loss.

The work plan called for the sampling of any seeps noted within the landfill mass. Diligent walks around the toe and southern sides revealed no seeps even though the period preceding our field work was one of the wettest on record. A small surface water stream was observed to travel along the northwestern toe of the fill and discharge into the detention pond at the southern toe of the fill. A small catchment was excavated to provide a stilling basin and sampling point for the flow. Once the flow had cleared a grab sample was obtained in sterile containers and preserved in accordance with accepted protocols. A

pathway?

sample of the sediment was also collected for laboratory analysis as a background check for possible landfill influences.

During our 11 days of field work our engineers had the opportunity to observe the waste stream and landfill operation practices. While these observations are not a direct part of the study, they provide insight into landfill/ site interaction which are used, in part, in the evaluation section of this report.

2.3 Laboratory Studies

Water samples obtained from the surface runoff discharge point and the monitoring wells were sent to Energy Labs in Billings for analysis in accordance with Table 1 of Section 16.14.706. Results are summarized in Table II, attached, while raw data are contained in Appendix B. The pond sediment sample was analyzed for the same parameters. Chain of custody and QA/QC for the lab are also included in the appendix.

Soil samples recovered from the borings and shelly tube sampling locations were tested for index properties and permeability. Water content tests were performed on all samples while grain size distribution, including hydrometer analysis, Atterberg limits, and *in situ* unit weights were performed on selected samples. All shelly tube samples were tested for permeability by ASTM D5084 (flexwall) methodology. Results of the tests are summarized in Tables III and IV, and on Plates 1 through 15. Tests were selected for correlative purposes. That is, Atterberg limits and grain size distribution can be used to evaluate permeability test results. *In situ* densities afford a comparison for the permeability tests on the relatively undisturbed shelly tube samples, and water content tests allow for determination of moisture penetration from the surface.

good
explanations

3.0 SITE CHARACTERISTICS

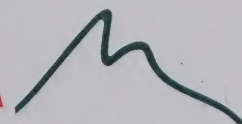
3.1 General Physiography

The Mister M landfill site is located in the SW1/4 of Section 8, T15N, R19E about 3 miles east of Lewistown, Montana. Prior to being used as a landfill, the area was a coulee extending southwestward from a northwest-southeast trending ridge. Older aerial photographs show the site was vegetated with grasses but no distinguishable brush or understory. Coloration of the vegetation was slightly darker in the bottom of the drainage but not markedly so. The coulee extended to the old railroad grade where it passed through a low bridge into a continuation of the coulee which is now partly entrance road and swale.

Fergus Co.

Topographically, the site is a self contained drainage unit as illustrated on Figure 6. The ridge which bounds the site along the northeast and northwest is at Elevation 4270± while the toe of the landfill is at Elevation 4195±. The detention pond at the toe had a water surface of 4192± at the time of our investigation. Topography continues as a gentle

4270
- 4192
= 78
of relief



slope to the south and west below the old railroad grade; the slope ultimately becomes the Boyd Creek drainage.

Surrounding topography is characteristic of dome and basin geology and comprises the Judith Mountains. The general slope and drainage of the southwest face of the mountains is towards the south with a minor westerly component. Review of USGS quadrangle maps and "windshield" reviews of the area suggest that drainage is fed primarily to Boyd and Breed Creeks.

Climate of the area is considered modified continental as described by Dightman (1966) and Feltis (1973). While climatological data are available only for the foothills of the Judith and Big Snowy Mountains, the area is representative of the Mister M site. Lewistown lies north and west of mountains (Judiths, Moccasins, Snowy's) which are apparently large enough to influence regional weather more than the east slope of the main Rocky Mountain chain. Winds become upslope in Fergus County rather than downslope as is the case with most areas east of the Continental Divide. Precipitation averages 16 inches per year with a 30 year range of 10 to 20 inches. *- airport data ?*

3.2 Surficial, Bedrock, and Structural Geology

The Lewistown area is topographically dominated by the Judith and Moccasin Mountains which are large Tertiary intrusive centers. Various porphyritic cores occur in these domal features. However, the study area for the Mister M landfill is primarily Cretaceous aged bedrock with residual and colluvial soils, flanked to the south by valley fill or alluvium. Old terrace remnants were also observed and were mapped by Feltis (1973).

Soils are primarily residual in nature and composed of silty to plastic clays which reflect the mineralogic composition of the parent shales and siltstones. Thickness is usually small although depths of 8 to 10 feet were drilled or excavated in our field explorations. Colluvium is limited to the toe of high wall cut at the northwest side of the landfill. Its makeup is primarily sandy clay. *- this far south ?*

The valley till is composed of a sand-clay mixture to depths of 4 to 10 feet followed by sand-gravel-cobble mixtures to depths of as much as 50 feet near Boyd Creek. The fill thins rapidly towards the north and south indicating that the coarser portion was deposited in a short time. *- ?*

The terrace remnants are sand-gravel-cobble mixtures located along the bench or ridge paralleling the north side of Hwy. 200. Reportedly, a larger quantity of this material was borrowed for railroad and highway roadbed construction in the area. A small remnant (500± square feet) was mapped as shown on Figure 2. Thickness is less than 8 feet and composition is primarily coarse to medium sand and fine to coarse gravel; silt content is

minimal. Porter (1991) mapped extensive terraces to the east of Lewistown. By elevation correlation, the remnants mapped by AGI appear to be Q_{12} , or mid-Quaternary.

Bedrock and structural geology have been investigated by Porter (1991) and Feltis (1973) as illustrated on Figures 3 and 5 attached. Feltis maps the area as **Cretaceous age Kootenai and Colorado Formations**. He describes the Colorado in the area as the basal sandstone or the First Cat Creek sand. Porter (1991) reviewed Feltis' work and named the same formation the **Fall River sandstone**. Porter's description:

FALL RIVER SANDSTONE. *Tan-brown-weathering, light gray-tan or buff-tan, predominantly fine-grained quartzose sandstone. Cross-stratified and rippled in thin to thick beds with numerous very thin dark shale partings. Interbedded dark, clayey to sandy shale. Invertebrate tracks and trails on bedding plane surfaces. Base of unit may be a sandstone or a medium gray sandy shale interval resting on Kootenai redbeds. Forms caps of benches south and east of Lewistown. Thickness varies from approximately 20 ft. to approximately 48 ft. over map area. Formation not mapped west of Judith Mountains because of poor exposures, though occasionally seen in float.*

is more descriptive and accurate based on our field mapping. Feltis' description of the basal Colorado:

Dark gray to black marine shale. The basal part is 20 to 80 feet of thin interbedded gray to brown sandstone and fissile black shale, which probably is equivalent to First Cat Creek sand of Cat Creek oil field, Petroleum and Garfield Counties, Montana.

does not seem to fit site conditions nearly as well as Porter.

The **Kootenai Formation** is predominantly shale ranging from red and maroon to gray-green and black. Structure is blocky especially in the buff colored (weathering) silty shales or shaley siltstones. Cross-stratified silty sandstones occur in the upper sections, and are tan to light brown with numerous chert and feldspathic zones. The basal unit is a gray to grayish white lenticular sandstone. Grain size is predominantly medium to coarse but can be conglomeratic. Basal unit thickness is variable but can be as thick as 100 feet. Overall formation thickness is thought to be 300 to 550 feet in the general area. Figure 4, derived from MBMG Map TP 217.07E, presents isocons of formation. Logs of local area water wells support these data. Figure 7, taken from our work plan, shows the location of those wells, and Appendix C contains the logs.

Dip of the formation is almost exclusively **southwest**, ranging from 6 to 12 degrees. **Strike** is orthogonal to the dip for the most part, and was measured at **N35 to 40W**.

Gardiner (1959) was the first (apparently) to map the geologic structure of the Lewistown area. Domal structures and the Warm Spring Syncline were mapped by Gardiner and used by Porter (1991) as a starting point for additional work. She mapped three additional domes (Duffy, Chippewa Creek, and Pan Creek) which forms a broad synclinal reentrant on the southeast flank of the Judith Mountains. The west and north trending Warm Spring Syncline is mapped to the west of the Mister M site. The Lewistown Bench Dome forms the southern edge of the Boyd Creek drainage. Drainages to the north and east of the landfill site appear to be defined by the western limb of the Warm Spring Syncline.

3.3 Geohydrology

Ground water within the Kootenai Formation is confined primarily to the basal or Third Cat Creek sandstone. The studies conducted at this site show that ground water within the upper 100 to 200 feet is, for practical purposes, nonexistent. Borings, test pits, and extensive visual observation yielded no ground evidence at any location within the site.

A very brief investigation by Hydrometrics (1979) found "ground water" in a test pit just downslope of our MW-1 and 8 cluster. However, subsequent measurements, as reported by the owners, and by our staff found no evidence of ground water in the well left by Hydrometrics. It is noteworthy that 1993 has been one of the wettest recorded years.

Well logs for water supply wells in the surrounding area show no indication of ground water until the basal sandstone is penetrated. Discussions with several area drillers revealed that moisture content within the Kootenai bedrock is low and would be categorized as "moist" for the wettest stratum.

A hydrologic study was performed to establish a preliminary water balance. Details of this work are presented in subsequent sections show that precipitation is balanced by soil moisture increase in the near surface weathered shales, evapotranspiration, and runoff.

The deep or basal sandstone aquifer ^{thickness of aquifer} is well known throughout its areal extent in Montana. Feltis developed ground water flow trends which are presented on Figure 4. Our data gathering had the advantage of at least 15 more wells than did Feltis. These data show a piezometric surface some 25 to 100 feet below grade with a flow to the west-southwest. Water quality is fair to good with high TDS and alkalinity as the primary problems.

4.0 EVALUATION OF GEOTECHNICAL DATA

4.1 Ground Water

The data gathered by subsurface exploration yielded no evidence of ground water, even adjacent to the detention pond. Literature reviews and field observations support the subsurface explorations as do field and laboratory tests. Flexwall permeability tests of

When are slug test data results & calculations?

subsurface explorations as do field and laboratory tests. Flexwall permeability tests of shelby tube samples have a geometric mean of 1×10^{-7} cm/sec while the borehole permeability tests have a mean of 1×10^{-6} cm/sec. The flexwall tests yield vertical permeability, K_v , and K_h is represented by the borehole tests. The mean permeability K_m is defined as:

$$K_m^{geom} = (1 \times 10^{-6} \cdot 1 \times 10^{-7})^{1/2}$$

$$K_m = (K_h K_v)^{1/2}$$

Substitution yields a K_m of 3.2×10^{-7} cm/sec. The transformation ratio, m , is determined from:

$$m = \left(\frac{1 \times 10^{-6}}{1 \times 10^{-7}} \right)^{1/2}$$

$$m = (K_h / K_v)^{1/2}$$

hi ratio =

Again by substitution, m is 3.2 which is reasonable for a material which was originally stratified.

Atterberg limits and hydrometer tests support the permeability data. All soils, which are weathered shales, range from silty to plastic clays, and have a significant colloidal fraction as determined by 24 hour hydrometer readings on representative samples.

The laboratory and field data support the concept of very limited infiltration by virtue of low vertical and horizontal permeability. A hydrologic evaluation was performed to assess observed stormwater runoff and runoff conditions. The entire analysis is presented as Appendix D and Figure 6 provides the basis of the analysis in terms of drainage areas. All catchment areas except No. 4 appear to discharge through the detention pond at the landfill toe. There is a possibility that catchment No. 1 acts as a detention area because of the borrow activities. For purposes of the analysis, however, it was assumed to discharge to the pond. Antecedent moisture conditions of I (dry) and II (normal) were used for 2, 10, and 25 year storms of 24 hour duration. The pond discharges small quantities for the 2 year storm and significantly larger for the 10 and 25 year events. According to the owners the pond actually overflows only once or twice per year which matches the analysis reasonably well. While topography data would help refine the analysis, the study shows that the water balance is composed of runoff and evapotranspiration and that infiltration is a very small segment of the water balance.

Water content tests which are summarized on Table III, show that the maximum occurs between 10 and 15 feet, and decreases below that. Water contents above 10 feet are close to or within the zone of seasonal moisture change. It follows that infiltration, if it exists to any extent, is restricted to the upper 10 feet and then only in very limited quantities.

4.2 Water and Sediment Quality

Water and sediment samples were analyzed for priority pollutants (EPA 624 long list) and RCRA metals in addition to standard leachate parameters. Table I-5 of Noble, Bergantino, et al (1982) is reproduced below for reference. The data reflect water quality for 130 samples of ground water from the Kootenai Formation.

Constituents and Standards	Number of Values Reported	% Greater Than Standard	% Less Than Standard	Average Concentration in MG/L
Na+ (250)	130	20	80	202.
Fe(.3)	130	46	54	1.2
Mn(.05)	121	28	72	.1
Cl(250)	130	4	96	78.
SO ₄ (250)	130	22	78	156.
N(10)	130	0	100	.5
D _s (500)	130	48	52	769.

Data for the three monitoring wells and the runoff sample are compiled in Table II. Comparisons of the two tables show little similarity. The water from the wells is significantly cleaner in terms of sodium, chlorides, sulfate, and dissolved solids. **Runoff has high nitrate, and a slightly acidic pH.** The nitrate is probably due to animal wastes from grazing horses and cattle, and possibly minor seeps from the landfill. The slightly acidic pH is probably related to the nitrites in terms of very weak acid formation at the base of the landfill.

The pond sediment was tested for the eight RCRA metals. Arsenic, silver, and mercury were below detection levels whereas barium, cadmium, chromium, and lead were slightly to somewhat above detection levels. Selenium, a heavy metal, was thought to be a testing anomaly until field observations, discussions with the owners, and consultation with the analytic lab yielded answers. **Selenium** is a stable metal with very little propensity for chemical reaction or in dissolution in water. It does, however, form very stable oxides at high temperatures. Leaching for the analytic extraction process is needed to release the bonds. Observations at the site revealed several **stockpiles** of an **ash-like** substance with a total volume of 4 to 6 cubic yards. The material is **boiler scale and ash** which is typically high in selenium because of high temperature reactions in the fire chamber. The owners use the material to sand the internal haul and entrance roads of landfill, and since most runoff is directed into the detention pond, it is apparent that the scale/ash is sedimenting

in it. The other detected metals are probably derived from the same source although the marine sediments of the Great Plains have small but measurable quantities of these metals.

4.3 Landfill Influences

While the general site environs have a rather disorganized appearance, the landfill proper appears to be operated and managed in a reasonable and prudent manner. The landfill area occupies approximately 15 acres with another 5 to 6 acres to the west and south which are used as a borrow source for daily cover. Cover is stockpiled near the active or working area with sufficient quantities for 5 to 6 working days.

The landfill accepts 10 to 30 tons of waste per day with an average of approximately 14 tons per day. We expect this average to increase in 1994 because of the closing several small county and/or municipal landfills in the region.

Waste is spread in uniform layers over the active area which is typically $\frac{1}{2}$ acre $\pm$ in area. It is compacted with a Caterpillar D9 dozer and covered at the end of the day with 8 to 12 inches of borrow. On windy days, the dozer operator may place a thin, interim cover to reduce the potential for blowing paper, etc.

The landfill has been shaped and graded to form a pronounced turtle back shape which drains in a 360° radius. Surface water is collected at the toe of the mass and routed to the storm pond. Examination of erosion features on covered areas of the landfill suggest runoff is high except for very dry periods when moisture demands of clayey cover soils absorb most of any precipitation event. Vegetation in the form of bunch grass and buffalo grass has been established on some areas which have been inactive for several years.

Review of aerial photographs suggest that the landfill was developed over its base area before vertical increases were incorporated into its operation. Therefore, the fill is predominantly horizontal layers of varying thickness.

As described in earlier sections, a very high percentage of precipitation is routed off site by runoff and evapotranspiration. Consequently, leachate generation is minimized. We believe the major leachate generator within this landfill is the moisture contained in the waste. Moisture tends to migrate to drier zones (vapor pressure) where cooler temperatures cause condensation. The condensation re-enters the waste mass where some is re-absorbed and the remainder begins the formation of leachate. The quantities are small since seeps were not in evidence over all of 1993. The leachate which makes it to the exterior of the fill is evaporated or used by vegetation; central Montana has a net evaporation loss of 20 $\pm$ inches per year.

Leachfields in semi-arid areas, (e.g. central Montana), provide an analogous situation. Although quantities of wastewater are applied to a relatively small area at a rate of 0.3 to

1.0 gallons per day per square foot, none is found a short distance downgradient of the field. In low permeability areas such as Great Falls, mound systems are used to provide effluent storage. Typically the effluent leaches at the toe of mound-clay interface and is evaporated in short order. Vegetation also utilizes the effluent. We believe that the Mister M landfill is behaving in a similar manner and will continue to do so provided shape and cover operations are maintained to promote surface runoff.

5.0 CONCLUSIONS

The field, office, and laboratory data gathered and evaluated during this study indicate the landfill area does not have a shallow ground water system, nor does the landfill generate sufficient leachate to impact its environs. The lack of a shallow ground water system and the presence of 250 to more than 400 feet of low to very low permeability sediments afford a significant level of protection to the basal Kootenai sandstone aquifer.

How was this thickness determined?
Confining layer?

Stratigraphy and soil/rock type are favorable for expansion of the landfill within the licensed area provided sufficient soils are stockpiled for interim and final closures.

not adequate, need permit

Storm water management, although not professionally designed, is effective for the size of the landfill. Expansion, final cover, and regulations will require that a formal storm water program be designed and implemented.

Are there same as M...?

Several 4-inch diameter wells were installed at locations which can serve as methane monitoring points; a monitoring program is being prepared under separate cover.

The landfill lacks a current operation and maintenance (O&M) program. Regulations require the preparation, use, and timely update of this program. In our opinion, a properly designed and implemented O&M program would enhance longevity and usefulness of the landfill.

ARM
Lastly, the regulations, specifically Sections 16.14.706 and 707 of Subchapter 7, require development of a ground water monitoring and sampling program. The landfill area does not have a shallow system which can be monitored in the normal sense envisioned by statute. However, it would be prudent to check each well on a twice yearly basis for the presence of ground water. Precipitation in the area is heaviest in the April-June and September-October periods. Allowing for basic time lag, monitoring at the end of June and October would yield the highest probability of finding ground water.

6.0 RECOMMENDATIONS

Subchapter 7 does not provide for the development of recommendations, other than for monitoring and sampling. In order to provide a complete engineering service we feel that the following recommendations warrant consideration.

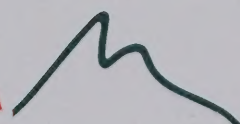
? HS study requires conclusions & recs for well etc.

1. Monitoring wells should be checked for ground water at the end of June and October each year. If ground water is encountered in other than a single location, DHES will be notified.
2. Operation of the landfill should continue in the present manner of operation with respect to shape, waste placement and compaction, and cover type. *Will require leachate collection system in expansion areas (a new footprint)*
3. An operation and maintenance (O&M) program should be designed and implemented as soon as possible. The O&M plan should incorporate methane monitoring.
4. A storm water management program should be designed and constructed. The program should take into account any expansions of the presently licensed area. *runoff permit?*

7.0 CLOSURE

This report has been prepared for specific application to the subject project and for the exclusive use of Mister M Disposal, Inc. The work was accomplished in accordance with generally accepted professional engineering and geologic practices consistent with the level of skill ordinarily practiced by members of the profession in the same locality under similar conditions. The report and findings shall not, in whole or part, be given to any party other than Montana DHES, without prior written consent of Abenaki Geoenvironmental, Inc.

files, open to public



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Lamb + Whitman

TABLE I

SUMMARY OF P.I.D. READINGS
MISTER M LANDFILL
LEWISTOWN, MONTANA

Boring No.	Sample Depth	P.I.D. Reading (ppm)
MW-1	4.5 - 6	<1
	9.5 - 11	<1
	15 - 20 (cuttings)	<1
MW-2	4 - 5.5	<1
	9 - 10.5	<1
	17 - 21 (cuttings)	<1
MW-3	4 - 5.5	<1
	9.5 - 11	<1
MW-4	4.5 - 6	<1
	10 - 11.5	<1
	14.5 - 16	<1
	18 - 20 (cuttings)	<1
MW-7	3 - 5 (cuttings)	<1
	9 - 12 (cuttings)	<1
	19 - 23 (cuttings)	<1
MW-8	2 - 5 (cuttings)	<1
	8 - 11 (cuttings)	<1
	18 - 20 (cuttings)	<1

TABLE II

SUMMARY OF ANALYTIC TESTS
MISTER M LANDFILL
LEWISTOWN, MONTANA

Constituent	MW-1 mg/l (ppm)	MW-2 mg/l (ppm)	MW-4 mg/l (ppm)	Runoff Into Pond mg/l (ppm)
Potassium	4	2	3	12
Sodium	12	21	23	41
Calcium	86	146	85	77
Magnesium	22	24	20	54
Sulfate	75	52	51	158
Chloride	16	47	28	68
Carbonate	0	0	0	0
Bicarbonate	315	356	251	245
Total Dissolved Solids @ 180°C	405	602	498	647
Total Alkalinity as CaCO ₃	258	291	206	201
Nitrate as N	0.77	<0.05	0.43	18.7
Specific Conductance @ 25°C (umhos/cm)	544	823	721	667
pH (units)	7.5	6.9	7.8	6.4
Ammonia as N	<0.1	<0.1	<0.1	0.4
Chemical Oxygen Demand	27	57	40	25
Total Suspended Solids	412	3430	16300	515
Dissolved Metals				
Arsenic	<0.005	<0.005	<0.005	<0.005
Barium	0.1	0.2	0.2	<0.01
Cadmium	<0.001	<0.001	0.003	<0.001
Chromium	<0.01	<0.01	<0.01	<0.01
Iron	<0.03	<0.03	<0.01	<0.03
Lead	<0.01	<0.01	0.03	<0.01
Manganese	<0.01	0.31	0.16	<0.01
Mercury	<0.001	<0.001	<0.001	<0.001
Selenium	<0.005	<0.005	<0.005	<0.005
Silver	<0.005	<0.005	<0.005	<0.005

TABLE II CONTINUED
SUMMARY OF ANALYTIC TESTS
MISTER M LANDFILL
LEWISTOWN, MONTANA

Constituent	MW-1 ug/l (ppb)	MW-2 ug/l (ppb)	MW-4 ug/l (ppb)	Runoff Into Pond ug/l (ppb)
Benzene	<1.0	<1.0	<1.0	<1.0
Bromochloromethane	<1.0	<1.0	<1.0	<1.0
Bromodichloromethane	<1.0	<1.0	<1.0	<1.0
cis-1,3-Dichloropropene	<1.0	<1.0	<1.0	<1.0
trans-1,3-Dichloropropene	<1.0	<1.0	<1.0	<1.0
1,4-Difluorobenzene	<1.0	<1.0	<1.0	<1.0
Ethylbenzene	<1.0	<1.0	<1.0	<1.0
Ethyl methacrylate	<1.0	<1.0	<1.0	<1.0
4-Bromofluorobenzene	<10	<10	<10	<10
Bromoform	<1.0	<1.0	<1.0	<1.0
Bromomethane	<1.0	<1.0	<1.0	<1.0
Carbon Tetrachloride	<1.0	<1.0	<1.0	<1.0
Chlorobenzene	<1.0	<1.0	<1.0	<1.0
Dibromochloromethane	<1.0	<1.0	<1.0	<1.0
Chloroethane	<1.0	<1.0	<1.0	<1.0
2-Chloroethyl vinyl ether	<1.0	<1.0	<1.0	<1.0
Chloroform	<1.0	<1.0	<1.0	<1.0
Chloromethane	<1.0	<1.0	<1.0	<1.0
Dibromomethane	<1.0	<1.0	<1.0	<1.0
Dichlorodifluoromethane	<1.0	<1.0	<1.0	<1.0
1,1-Dichloroethane	<1.0	<1.0	<1.0	<1.0
1,2-Dichloroethane	<1.0	<1.0	<1.0	<1.0
Iodomethane	<1.0	<1.0	<1.0	<1.0
Methylene chloride	<1.0	<1.0	<1.0	<1.0
1,1-Dichloroethene	<1.0	<1.0	<1.0	<1.0
trans-1,2-Dichloroethene	<1.0	<1.0	<1.0	<1.0
Styrene	<1.0	<1.0	<1.0	<1.0
1,1,2,2-Tetrachloroethane	<1.0	<1.0	<1.0	<1.0
Toluene	1.2	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	<1.0*	<1.0	<1.0	<1.0
1,1,2-Trichloroethane	<1.0	<1.0	<1.0	<1.0
Trichloroethene	<1.0	<1.0	<1.0	<1.0
Trichlorofluoromethane	<1.0	<1.0	<1.0	<1.0
1,2,3-Trichloropropane	<1.0	<1.0	<1.0	<1.0
Vinyl acetate	<1.0	<1.0	<1.0	<1.0
Vinyl chloride	<1.0	<1.0	<1.0	<1.0
Xylenes	<1.0	<1.0	<1.0	<1.0
Tetrachloroethene	<1.0	<1.0	<1.0*	<1.0

Note: *indicates present but less than practical quantitation limits.

TABLE II CONTINUED

SUMMARY OF ANALYTIC TESTS MISTER M LANDFILL LEWISTOWN, MONTANA POND SEDIMENT ANALYSIS RESULTS

Purgable Organic Constituents

<u>Constituent</u>	<u>µg/g (ppm)</u>	<u>Constituent</u>	<u>µg/g (ppm)</u>
Acetone	< 10	2,2-Dichloropropane	< 0.20
Acrolein	< 4.0	1,1-Dichloropropene	< 0.20
Acrylonitrile	< 4.0	cis-1,3-Dichloropropene	< 0.20
Benzene	< 0.20	trans-1,3-Dichloropropene	< 0.20
Bromobenzene	< 0.20	Ethylbenzene	< 0.20
Bromochloromethane	< 0.20	Hexachlorobutadiene	< 0.20
Bromodichloromethane	< 0.20	2-Hexanone	< 4.0
Bromoform	< 0.20	Iodomethane	< 0.20
Bromomethane	< 0.20	Isopropylbenzene	< 0.20
2-Butanone (Methyl Ethyl Ketone)	< 4.0	p-Isopropyltoluene	< 0.20
n-Butylbenzene	< 0.20	4-Methyl-2-pentanone (MIBK)	< 4.0
sec-Butylbenzene	< 0.20	Methylene chloride (Dichloromethane)	< 0.20
tert-Butylbenzene	< 0.20	Naphthalene	< 0.20
Carbon disulfide	< 0.20	n-Propylbenzene	< 0.20
Carbon tetrachloride	< 0.20	Styrene	< 0.20
Chlorobenzene	< 0.20	Tetrachloroethene	< 0.20
Chlorodibromomethane	< 0.20	(Tetrachloroethylene)	
Chloroethane	< 0.20	1,1,1,2-Tetrachloroethane	< 0.20
2-Chloroethyl vinyl ether	< 0.20	1,1,2,2-Tetrachloroethane	< 0.20
Chloroform	< 0.20	1,2,3-Trichlorobenzene	< 0.20
Chloromethane	< 0.20	1,2,4-Trichlorobenzene	< 0.20
2-Chlorotoluene	< 0.20	1,1,1-Trichloroethane	< 0.20
4-Chlorotoluene	< 0.20	1,1,2-Trichloroethane	< 0.20
1,2-Dibromo-3- chloropropane (DBCP)	< 0.20	Trichloroethene	< 0.20
1,2-Dibromoethane (EDB)	< 0.20	(Trichloroethylene)	
Dibromomethane	< 0.20	Trichlorofluoromethane	< 0.20
1,2-Dichlorobenzene	< 0.20	1,2,3-Trichloropropane	< 0.20
1,3-Dichlorobenzene	< 0.20	1,2,4-Trimethylbenzene	< 0.20
1,4-Dichlorobenzene	< 0.20	1,3,5-Trimethylbenzene	< 0.20
Dichlorodifluoromethane	< 0.20	Toluene	< 0.20
1,1-Dichloroethane	< 0.20	Vinyl acetate	< 0.20
1,2-Dichloroethane	< 0.20	Vinyl chloride	< 0.20
1,1-Dichloroethene	< 0.20	(chloroethene)	
cis-1,2-Dichloroethene	< 0.20	Xylenes:	< 0.20
trans-1,2-Dichloroethene	< 0.20		
1,2-Dichloropropane	< 0.20		
1,3-Dichloropropane	< 0.20		

M
P
O

Selected Metallic Constituents

<u>Total Metals</u>	<u>µg/g (ppm)</u>
Arsenic	<5
Barium	76
Cadmium	2
Chromium	9
Lead	9
Mercury	<1
Selenium	250
Silver	<5

TABLE III

SUMMARY OF INDEX PROPERTIES TESTS
MISTER M LANDFILL
LEWISTOWN, MONTANA

Boring No.	Sample Depth	In Situ Water Content %	Liquid Limit	Plasticity Index	% Passing No. 200 (1)
MW-1	5 - 6.5		42	25	83
	9.5 - 11.0	12	26	11	
MW-2	4 - 5.5		27	10	69
	9 - 10.5	17	52	29	
	20 - 23	13			
MW-3	4 - 5.5		43	19	91
	9 - 10.5	10			
	16 - 20	9			
	20 - 25	9			
MW-4	4 - 5.5	9			22
	9 - 10.5	13			
	14 - 14.8	14			
	14.8 - 15.5	8			
Pond Sediment	0 - 0.5	19	23	9	22

(1) See Plate Nos. 7 through 10 for hydrometer analyses.

TABLE IV

SUMMARY OF SHELBY TUBE SAMPLE PERMEABILITIES
MISTER M LANDFILL
LEWISTOWN, MONTANA

Shelby Tube No.	Depth, Ft.	Unit Weight, pcf	Water Content, %	Permeability, cm/sec
ST-1	0.5 - 1.8	84	18	1.18×10^{-7}
ST-2	0 - 1.5	115	14	1.16×10^{-7}
ST-3	0 - 1.5	112	9	1.52×10^{-7}
ST-4	0 - 1.6	133	11	5.84×10^{-8}
ST-5	0 - 1.4	90	16	4.3×10^{-7}

Note: See Plate Nos. 11 through 15.

TABLE V

SUMMARY OF BORE HOLE PERMEABILITY TESTS
MISTER M LANDFILL
LEWISTOWN, MONTANA

Depth of
waste?
720'
~40'

Boring No.	Screen Interval, Ft. Below Ground		Permeability, cm/sec
	From	To	
MW-1	2	22	7.4×10^{-7}
MW-2	2	22	6.2×10^{-6}
MW-4	10	20	1×10^{-5}
MW-8	10	20	8×10^{-7}

GEOMORPHOLOGIC SITE CHARACTERIZATION
MISTER M LANDFILL
LEWISTOWN, MONTANA
LOCUS MAP



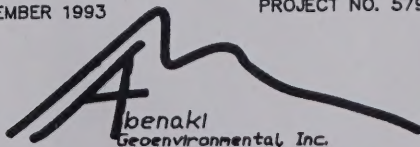
SCALE 1" = 22 MI (APPROX.)

FROM MONTANA CENTENNIAL HIGHWAY MAP (1990)

GEOHYDROLOGIC SITE CHARACTERIZATION MISTER M LANDFILL LEWISTOWN, MONTANA LOCUS MAP

NOVEMBER 1993

PROJECT NO. 579-03



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FIGURE 1

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ITE CHARACTERIZATION
ANDFILL
TANA

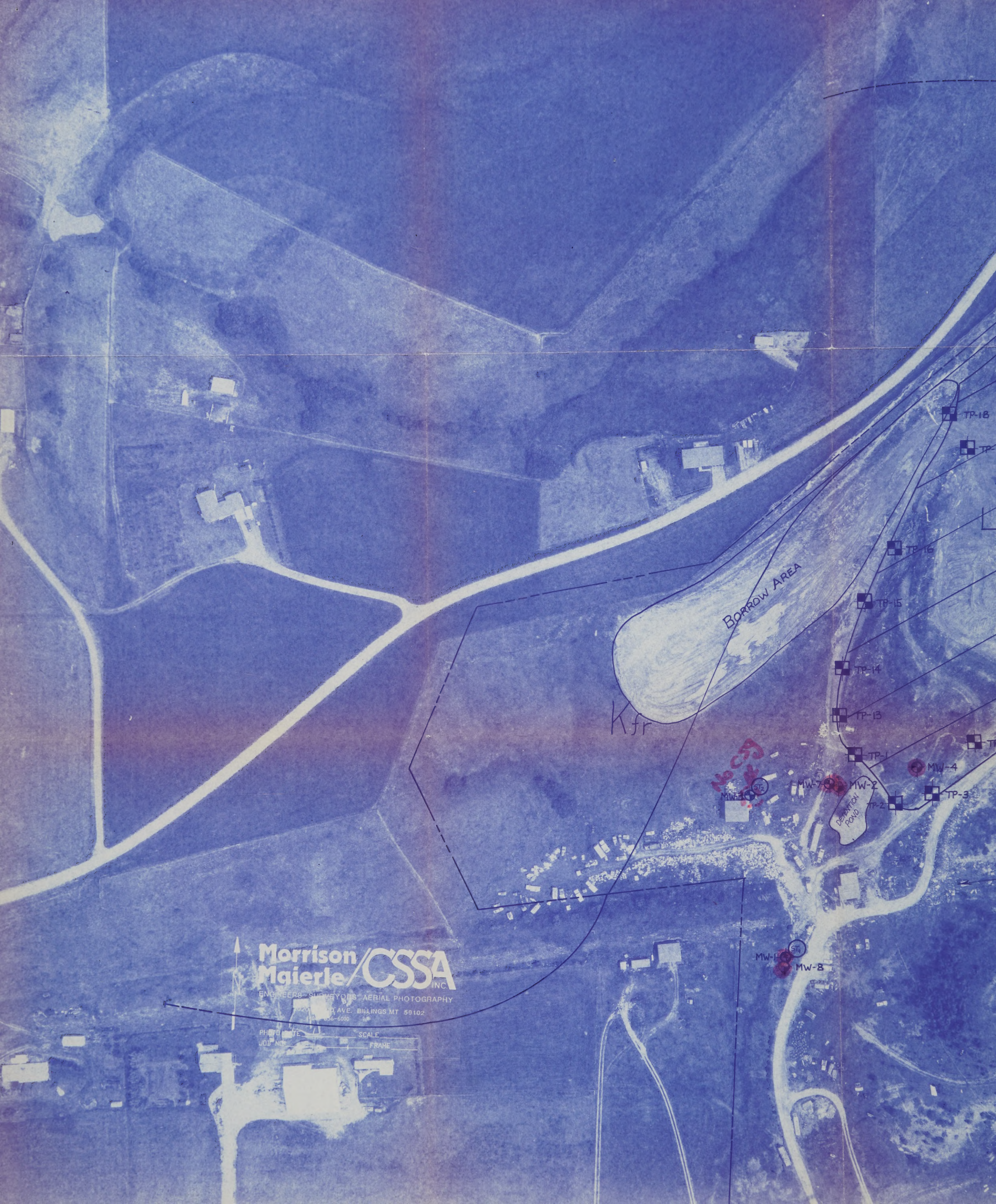
rficial Geology

FIGURE 2

11-15-93

fig 2

93-94- Part 1



Morrison
Majerle **CSSA** INC.

ENGINEERS SURVEYORS AERIAL PHOTOGRAPHY

7020 N. 10TH AVE. BILLINGS MT 59102

(406) 536-6000

PHOTO
JOB NO.

SCALE

FRAME

DRAFT

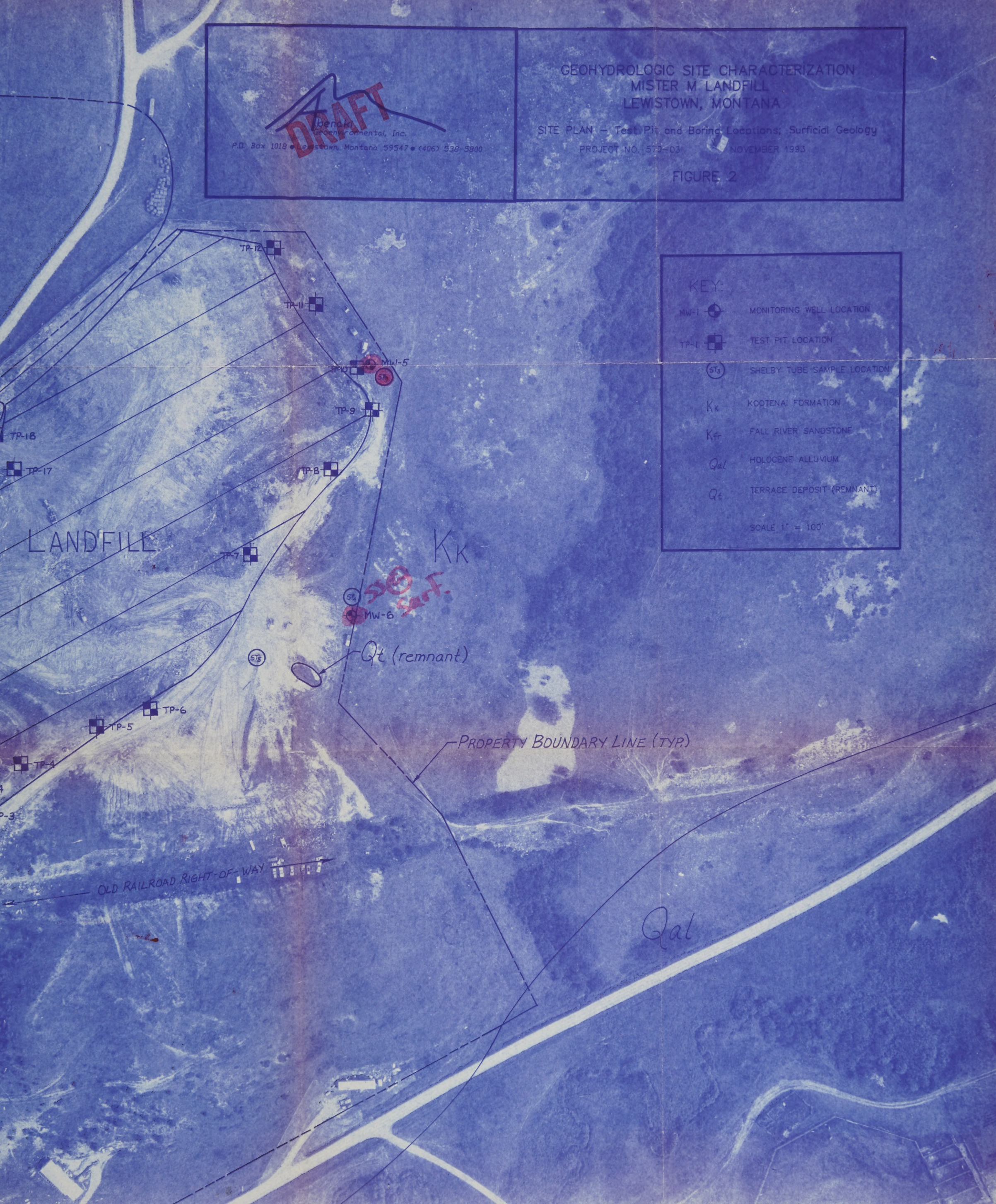
Benaki
Environmental, Inc.
P.O. Box 1018 • Lewistown, Montana 59547 • (406) 538-5800

GEOHYDROLOGIC SITE CHARACTERIZATION
MISTER M LANDFILL
LEWISTOWN, MONTANA

SITE PLAN — Test Pit and Boring Locations; Surficial Geology

PROJECT NO. 579-03 NOVEMBER 1993

FIGURE 2



KEY:

MW-1 MONITORING WELL LOCATION

TP-1 TEST PIT LOCATION

ST-3 SHELBY TUBE SAMPLE LOCATION

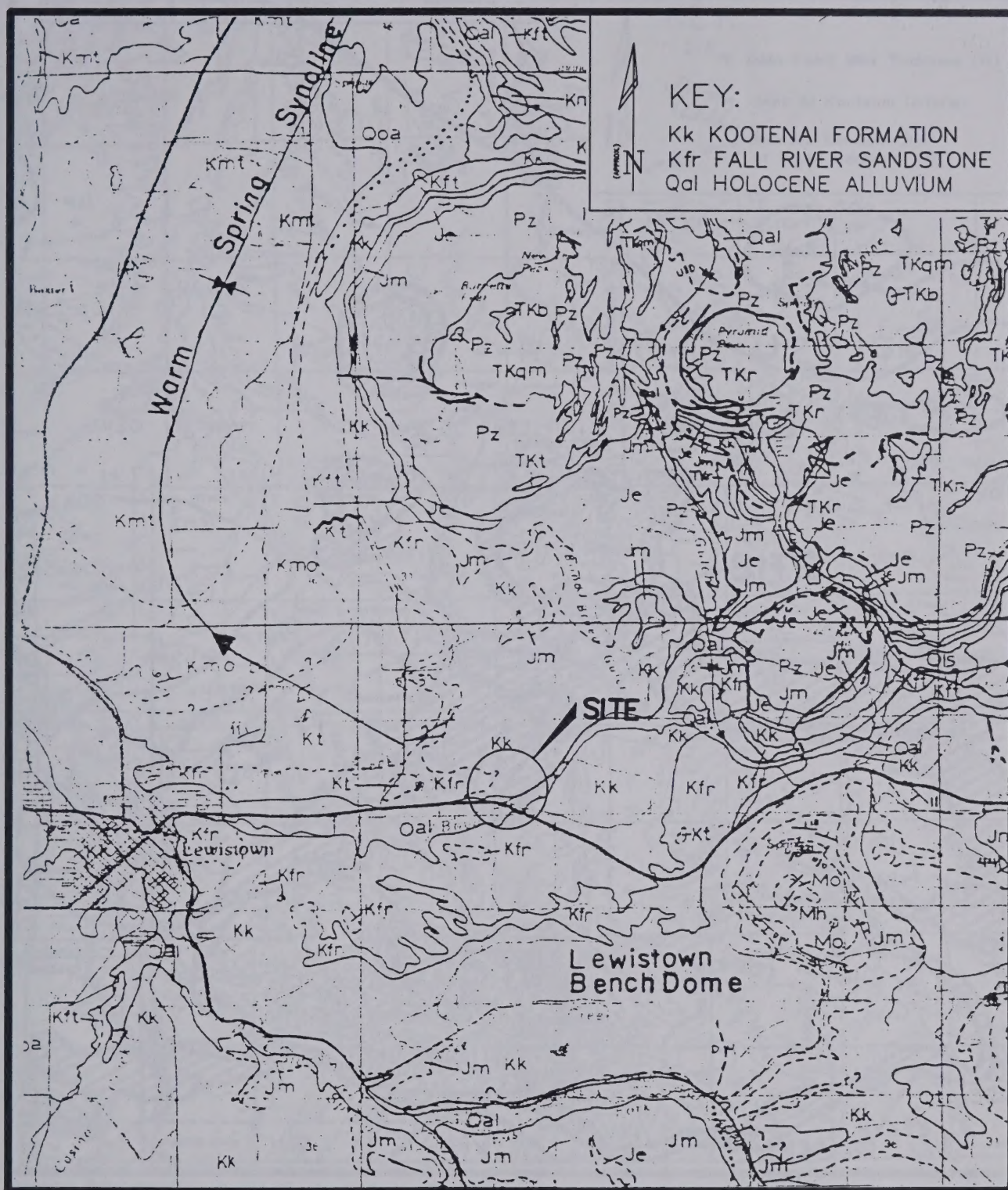
Kk KOOTENAI FORMATION

Kfr FALL RIVER SANDSTONE

Qal HOLOCENE ALLUVIUM

Qt TERRACE DEPOSIT (REMNANT)

SCALE 1" = 100'



GEOHYDROLOGIC SITE CHARACTERIZATION
MISTER M LANDFILL
LEWISTOWN, MONTANA

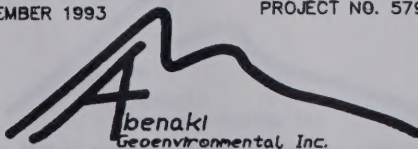
GEOLOGY BY K. PORTER (1991)

LEWISTOWN, MONTANA

GEOLOGY BY K. PORTER (1991)

NOVEMBER 1993

PROJECT NO. 579-03



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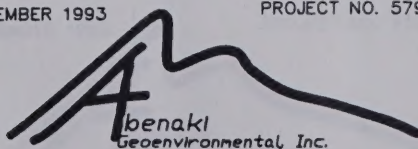
ADAPTED FROM MGMB Map TF 217.70E after Feltis and Others

GEOHYDROLOGIC SITE CHARACTERIZATION MISTER M LANDFILL LEWISTOWN, MONTANA

THICKNESS OF THE KOOTENAI FORMATION

NOVEMBER 1993

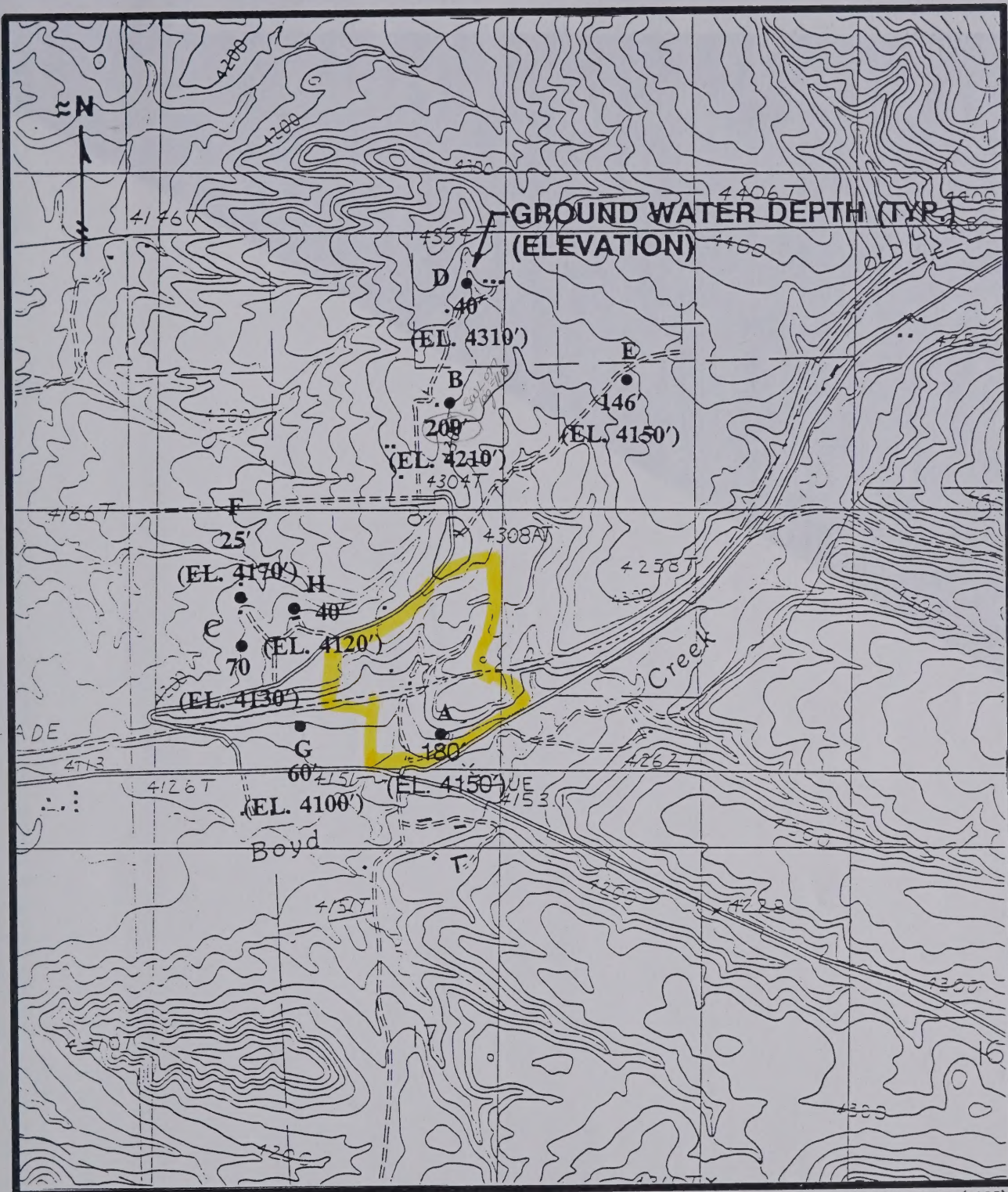
PROJECT NO. 579-03



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FIGURE 4

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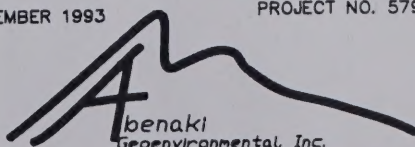
SCALE 1" = 2800' (APPROX.)

USGS PINE CREEK, MONTANA QUAD (1985)

GEOHYDROLOGIC SITE CHARACTERIZATION
 MISTER M LANDFILL
 LEWISTOWN, MONTANA
 EXISTING WATER WELL LOCATIONS AND GROUND WATER DEPTHS

NOVEMBER 1993

PROJECT NO. 579-03



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FIGURE 6

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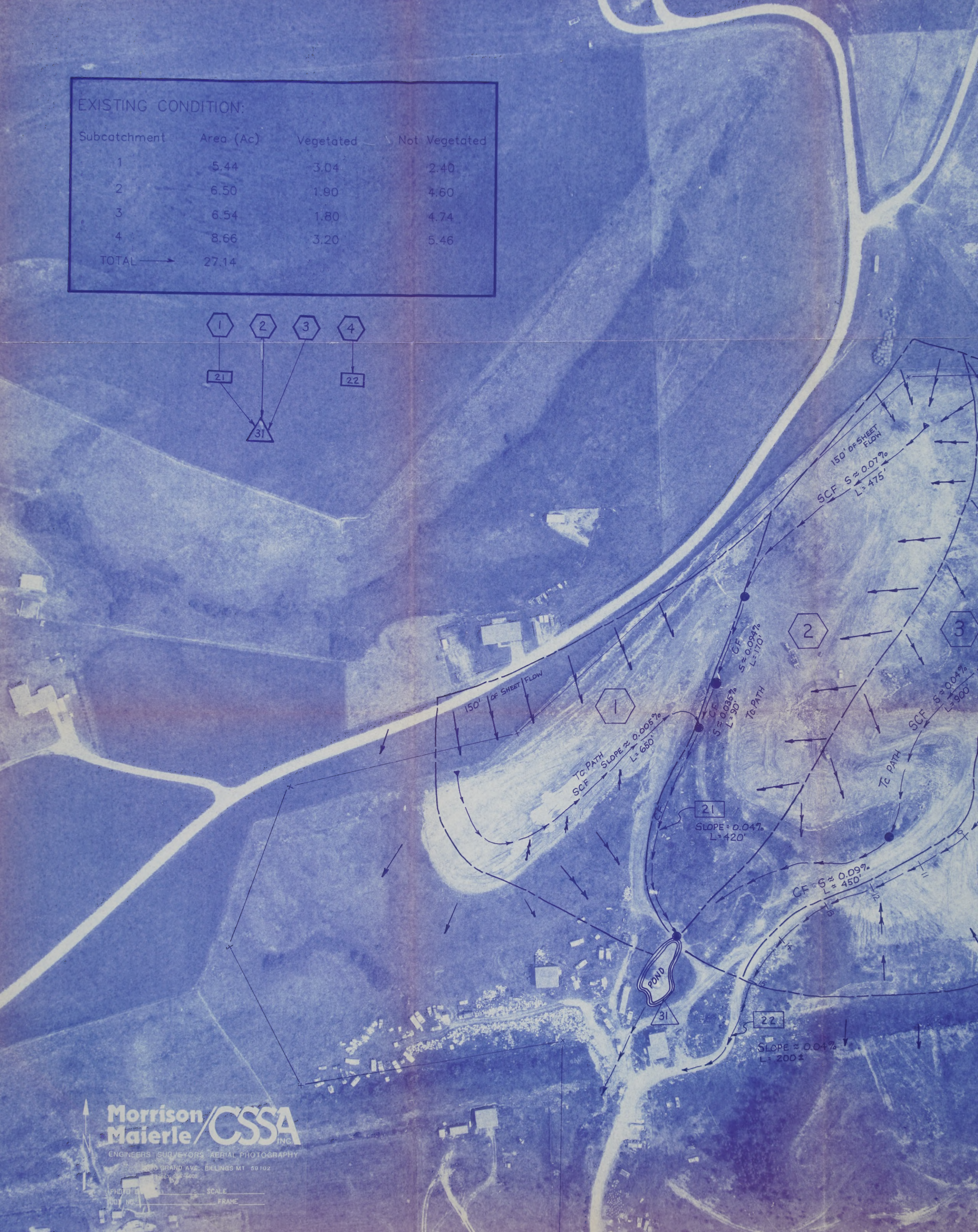
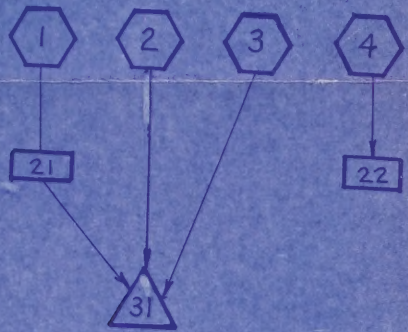
Outline site!

fig 7

FIGURE 7

EXISTING CONDITION:

Subcatchment	Area (Ac)	Vegetated	Not Vegetated
1	5.44	3.04	2.40
2	6.50	1.90	4.60
3	6.54	1.80	4.74
4	8.66	3.20	5.46
TOTAL	27.14		



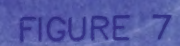
Morrison
Majerle / **CSSA** INC.

ENGINEERS SURVEYORS AERIAL PHOTOGRAPHY

1000 BRAND AVE. BILLINGS MT 59102

PHONE (406) 251-2000

PHOTO 1:10000 SCALE



11-15-93

fig 7

93-94

part 1

ATTERBERG LIMITS

PROJECT Mr. M Landfill	PROJECT NUMBER 579-03	TESTED BY DCH/CHM	BORING NUMBER MW-1 5-6.5 Ft.
LOCATION Lewistown, Montana	CHECKED BY MDA	SAMPLE NUMBER 1335A	
SAMPLE DESCRIPTION Silty Clay (CL)	DATE Tue Jul 06 1993	FILENAME 1335A	

LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER	c2	c3	e2		
WT. WET SOIL + TARE	18.09	16.75	18.2		
WT. DRY SOIL + TARE	15.06	13.9	14.89		
WT. WATER	3.03	2.85	3.31		
TARE WT.	6.45	6.32	8.65		
WT. DRY SOIL	8.61	7.58	6.24		
WATER CONTENT, W_N (%)	35.19	37.60	53.04		
NUMBER OF BLOWS, N	38	27	16		
ONE-POINT LIQUID LIMIT, LL	37.02	37.95	50.26		

PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER	a7	b1	d1		
WT. WET SOIL + TARE	10.34	10.06	9.6		
WT. DRY SOIL + TARE	9.78	9.49	9.09		
WT. WATER	0.56	0.57	0.51		
TARE WT.	6.05	6.19	6.34		
WT. DRY SOIL	3.73	3.3	2.75		
WATER CONTENT (%)	15.01	17.27	18.55		

SUMMARY OF RESULTS

NATURAL WATER CONTENT, W (%)	
LIQUID LIMIT, LL	42.3
PLASTIC LIMIT, PL	16.9
PLASTICITY INDEX, PI	25.4
LIQUIDITY INDEX, LI^*	

$$*LI = (W - PL)/PI$$

PLASTICITY CHART

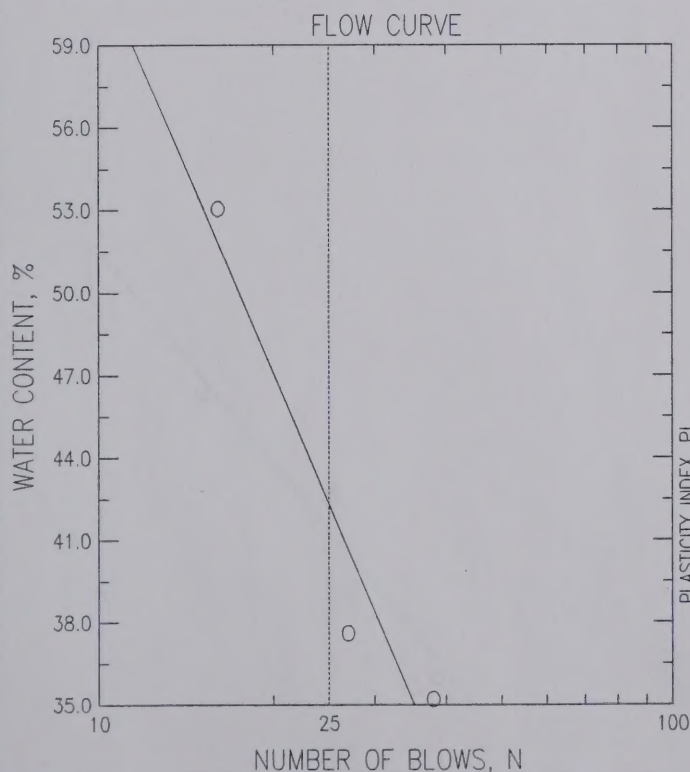
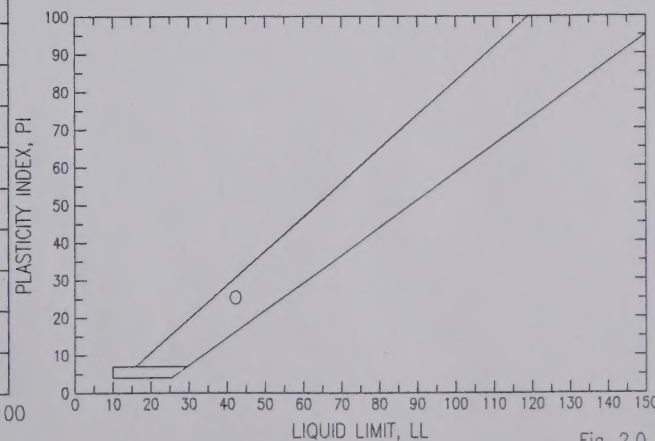


Fig. 2.0

ATTERBERG LIMITS

PROJECT Mr. M Landfill	PROJECT NUMBER 579-03	TESTED BY DCH/CHM	BORING NUMBER MW-1 9.5-11 Ft.
LOCATION Lewistown, Montana	CHECKED BY MDA	SAMPLE NUMBER 1335B	FILENAME 1335B
SAMPLE DESCRIPTION Clayey Silt/Silty Clay (CL-ML)	DATE Tue Jul 06 1993		

LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER	A6	A3	B3		
WT. WET SOIL + TARE	15.8	13.73	16.32		
WT. DRY SOIL + TARE	14	12.19	14.13		
WT. WATER	1.8	1.54	2.19		
TARE WT.	6.6	6.38	6.25		
WT. DRY SOIL	7.4	5.81	7.88		
WATER CONTENT, w_N (%)	24.32	26.51	27.79		
NUMBER OF BLOWS, N	38	25	15		
ONE-POINT LIQUID LIMIT, LL	25.59	26.51	26.13		

PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER	B2	A5	A9		
WT. WET SOIL + TARE	11.18	10.05	10.98		
WT. DRY SOIL + TARE	10.55	9.58	10.32		
WT. WATER	0.63	0.47	0.66		
TARE WT.	6.5	6.37	6		
WT. DRY SOIL	4.05	3.21	4.32		
WATER CONTENT (%)	15.56	14.64	15.28		

SUMMARY OF RESULTS

NATURAL WATER CONTENT, w (%)	
LIQUID LIMIT, LL	26.1
PLASTIC LIMIT, PL	15.2
PLASTICITY INDEX, PI	10.9
LIQUIDITY INDEX, LI^*	

$$*LI = (w - PL)/PI$$

PLASTICITY CHART

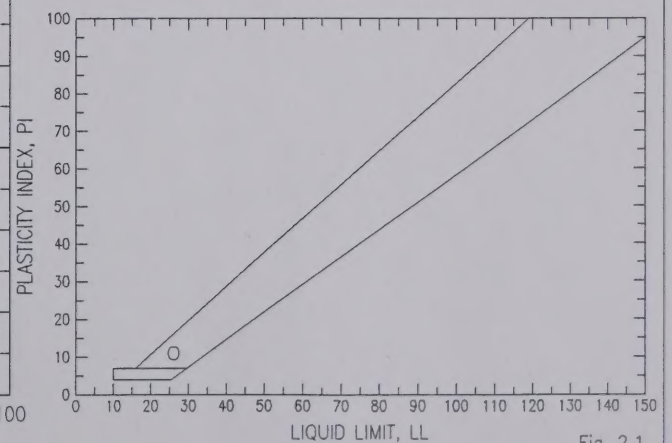
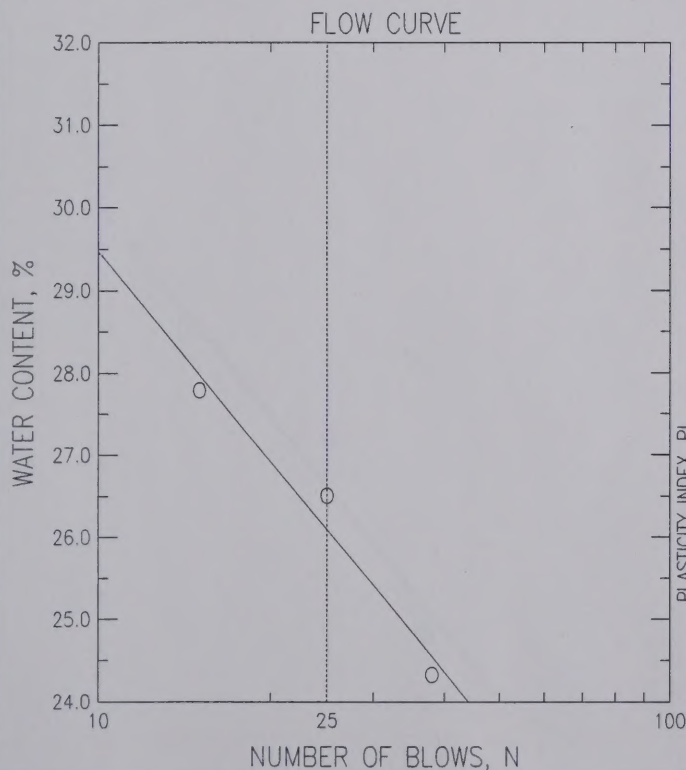


Fig. 2.1

ATTERBERG LIMITS

PROJECT Mr. M Landfill	PROJECT NUMBER 579-03	TESTED BY DCH/CHM	BORING NUMBER MW-2 4-5.5 Ft.
LOCATION Lewistown, Montana	CHECKED BY MDA	SAMPLE NUMBER 1335C	
SAMPLE DESCRIPTION Clayey Silt/Silty Clay (CL-ML)	DATE Tue Jul 06 1993	FILENAME 1335C	

LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER	N1	E1	A4		
WT. WET SOIL + TARE	14.14	14.88	13.74		
WT. DRY SOIL + TARE	12.57	13.05	12.06		
WT. WATER	1.57	1.83	1.68		
TARE WT.	6.24	6.32	6.17		
WT. DRY SOIL	6.33	6.73	5.89		
WATER CONTENT, w_N (%)	24.80	27.19	28.52		
NUMBER OF BLOWS, N	37	25	14		
ONE-POINT LIQUID LIMIT, LL	26.01	27.19	26.59		

PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER	A11	A2	A3		
WT. WET SOIL + TARE	9.27	9.04	9.63		
WT. DRY SOIL + TARE	8.82	8.64	9.15		
WT. WATER	0.45	0.4	0.48		
TARE WT.	6.01	6.31	6.32		
WT. DRY SOIL	2.81	2.33	2.83		
WATER CONTENT (%)	16.01	17.17	16.96		

SUMMARY OF RESULTS

NATURAL WATER CONTENT, w (%)	
LIQUID LIMIT, LL	26.6
PLASTIC LIMIT, PL	16.7
PLASTICITY INDEX, PI	9.9
LIQUIDITY INDEX, LI^*	

$$*LI = (w - PL)/PI$$

PLASTICITY CHART

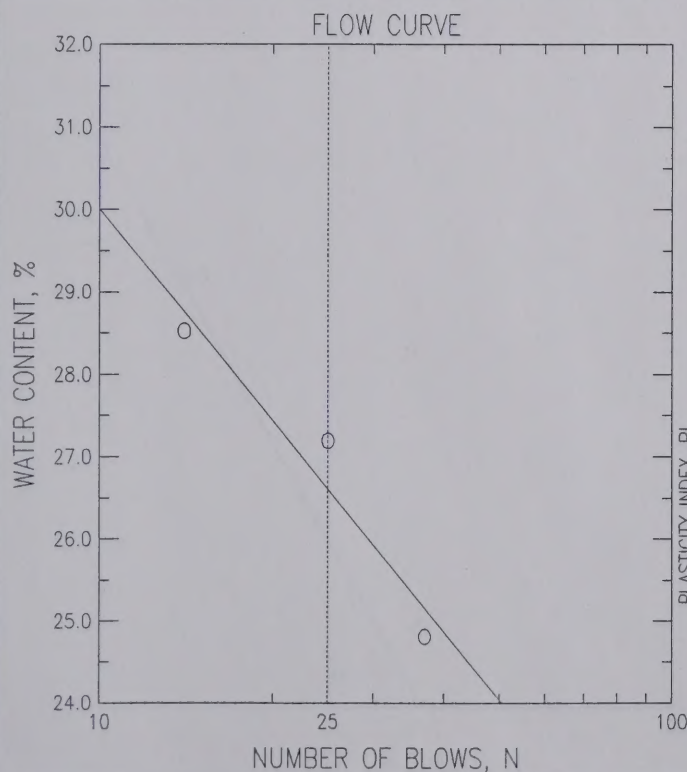
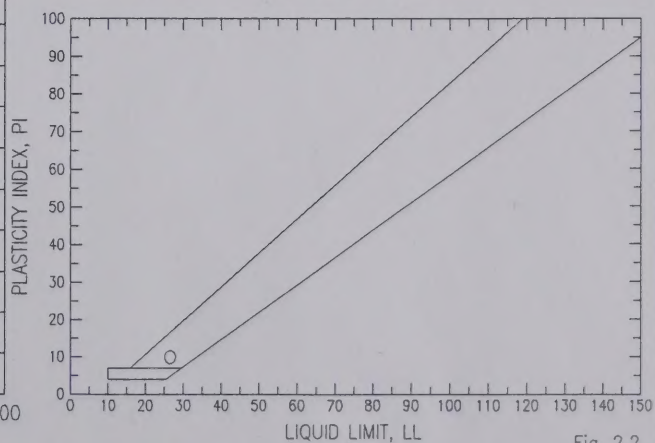


Fig. 2.2

ATTERBERG LIMITS

PROJECT Mr. M Landfill	PROJECT NUMBER 579-03	TESTED BY DCH/CHM	BORING NUMBER MW-2 9-10.5 Ft.
LOCATION Lewistown, Montana	CHECKED BY MDA	SAMPLE NUMBER 1335D	
SAMPLE DESCRIPTION Clay (CH)	DATE Tue Jul 06 1993	FILENAME 1335D	

LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER	B3	B1	A11		
WT. WET SOIL + TARE	15.82	14.74	16.51		
WT. DRY SOIL + TARE	12.65	11.91	12.78		
WT. WATER	3.17	2.83	3.73		
TARE WT.	6.43	6.29	6.03		
WT. DRY SOIL	6.22	5.62	6.75		
WATER CONTENT, W_N (%)	50.96	50.36	55.26		
NUMBER OF BLOWS, N	36	26	15		
ONE-POINT LIQUID LIMIT, LL	53.26	50.60	51.95		

PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER	A4	E1	N1		
WT. WET SOIL + TARE	12.18	12.73	13.7		
WT. DRY SOIL + TARE	11.07	11.55	12.31		
WT. WATER	1.11	1.18	1.39		
TARE WT.	6.21	6.38	6.32		
WT. DRY SOIL	4.86	5.17	5.99		
WATER CONTENT (%)	22.84	22.82	23.21		

SUMMARY OF RESULTS

NATURAL WATER CONTENT, W (%)	
LIQUID LIMIT, LL	52.0
PLASTIC LIMIT, PL	23.0
PLASTICITY INDEX, PI	29.0
LIQUIDITY INDEX, LI^*	

$$*LI = (W - PL)/PI$$

PLASTICITY CHART

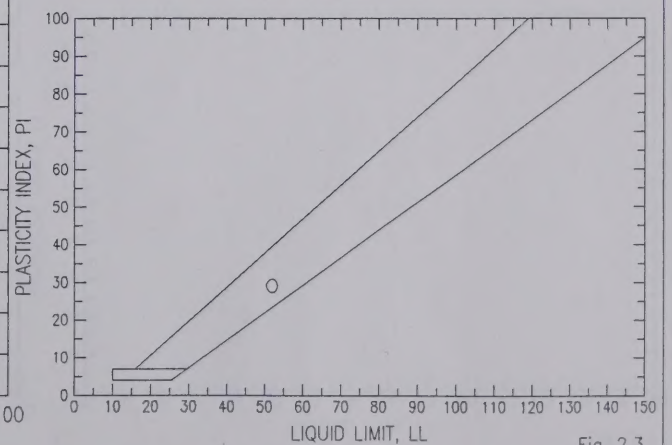
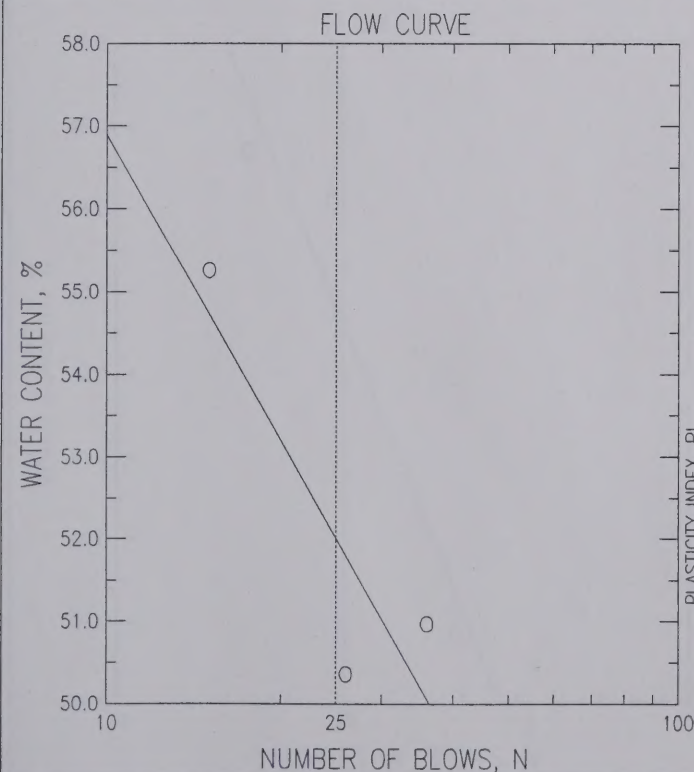


Fig. 2.3

ATTERBERG LIMITS

PROJECT Mr. M Landfill	PROJECT NUMBER 579-03	TESTED BY DCH/CHM	BORING NUMBER MW-3 4-5.5 Ft.
LOCATION Lewistown, Montana	CHECKED BY MDA	SAMPLE NUMBER 1335E	FILENAME 1335E
SAMPLE DESCRIPTION Clayey Silt/Silty Clay (CL)	DATE Tue Jul 06 1993		

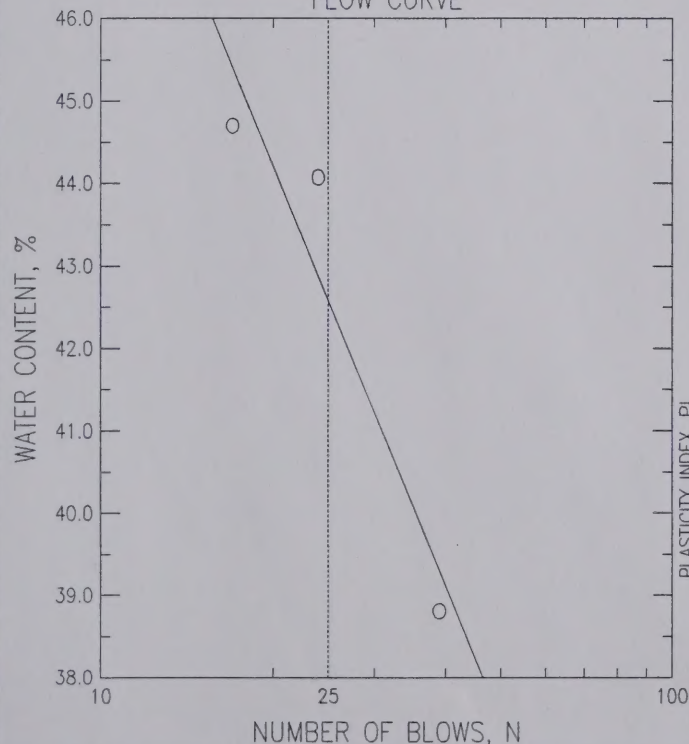
LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER	A6	A5	B2		
WT. WET SOIL + TARE	13.1	16.19	14.71		
WT. DRY SOIL + TARE	11.28	13.18	12.18		
WT. WATER	1.82	3.01	2.53		
TARE WT.	6.59	6.35	6.52		
WT. DRY SOIL	4.69	6.83	5.66		
WATER CONTENT, w_N (%)	38.81	44.07	44.70		
NUMBER OF BLOWS, N	39	24	17		
ONE-POINT LIQUID LIMIT, LL	40.95	43.85	42.66		

PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER	A3	A2	A9		
WT. WET SOIL + TARE	9.44	8.76	9.86		
WT. DRY SOIL + TARE	8.85	8.3	9.12		
WT. WATER	0.59	0.46	0.74		
TARE WT.	6.32	6.25	6		
WT. DRY SOIL	2.53	2.05	3.12		
WATER CONTENT (%)	23.32	22.44	23.72		

FLOW CURVE



SUMMARY OF RESULTS

NATURAL WATER CONTENT, w (%)	
LIQUID LIMIT, LL	42.6
PLASTIC LIMIT, PL	23.2
PLASTICITY INDEX, PI	19.4
LIQUIDITY INDEX, LI^*	

$$*LI = (W - PL)/PI$$

PLASTICITY CHART

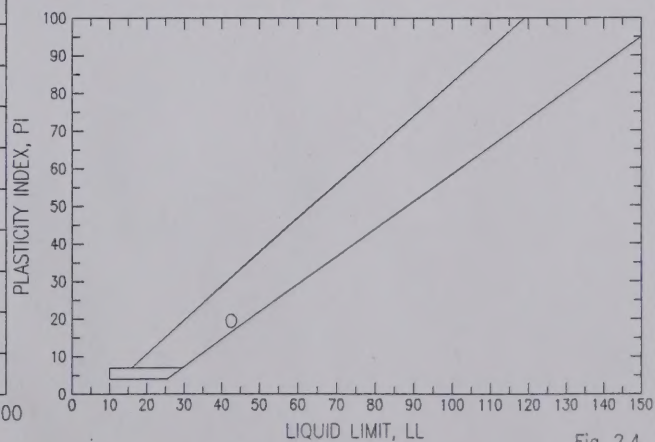


Fig. 2.4

ATTERBERG LIMITS

PROJECT Mr. M Landfill	PROJECT NUMBER 579-03	TESTED BY DCH/CHM	BORING NUMBER
LOCATION Detention Pond	CHECKED BY MDA	SAMPLE NUMBER 1335G	
SAMPLE DESCRIPTION Clayey Silt/Silty Clay (CL-ML)	DATE Tue Jul 06 1993	FILENAME 1335G	

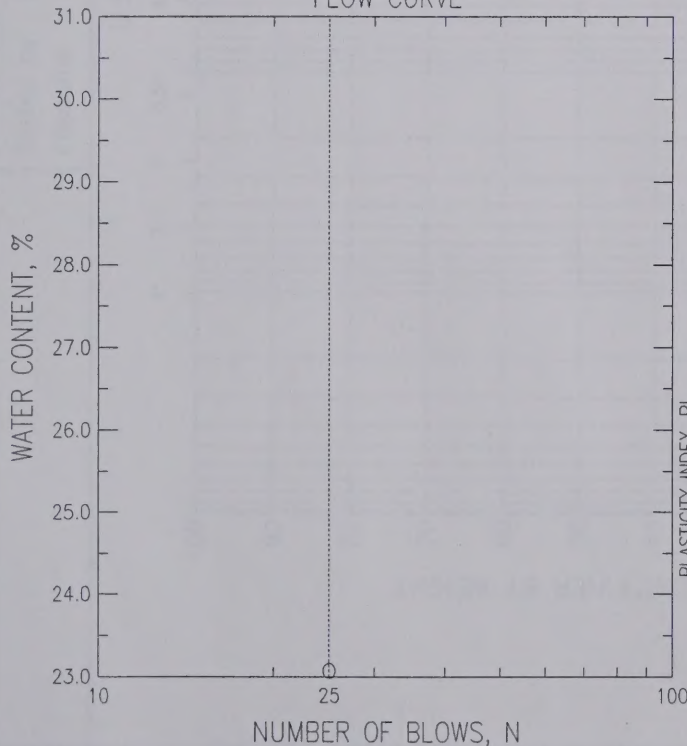
LIQUID LIMIT DETERMINATIONS

CONTAINER NUMBER	A3				
WT. WET SOIL + TARE	19.45				
WT. DRY SOIL + TARE	17				
WT. WATER	2.45				
TARE WT.	6.38				
WT. DRY SOIL	10.62				
WATER CONTENT, W_N (%)	23.07				
NUMBER OF BLOWS, N	25				
ONE-POINT LIQUID LIMIT, LL	23.07				

PLASTIC LIMIT DETERMINATIONS

CONTAINER NUMBER	C2	D1	C3		
WT. WET SOIL + TARE	15.42	17.18	16.5		
WT. DRY SOIL + TARE	14.31	15.9	15.31		
WT. WATER	1.11	1.28	1.19		
TARE WT.	6.52	6.41	6.38		
WT. DRY SOIL	7.79	9.49	8.93		
WATER CONTENT (%)	14.25	13.49	13.33		

FLOW CURVE



SUMMARY OF RESULTS

NATURAL WATER CONTENT, W (%)	
LIQUID LIMIT, LL	23.1
PLASTIC LIMIT, PL	13.7
PLASTICITY INDEX, PI	9.4
LIQUIDITY INDEX, LI*	

$$*LI = (W - PL)/PI$$

PLASTICITY CHART

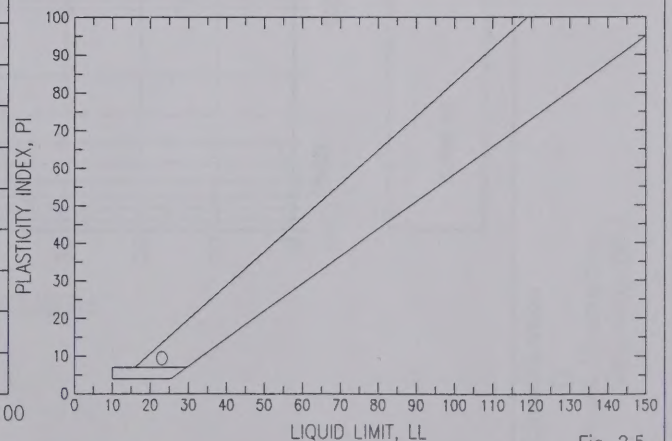
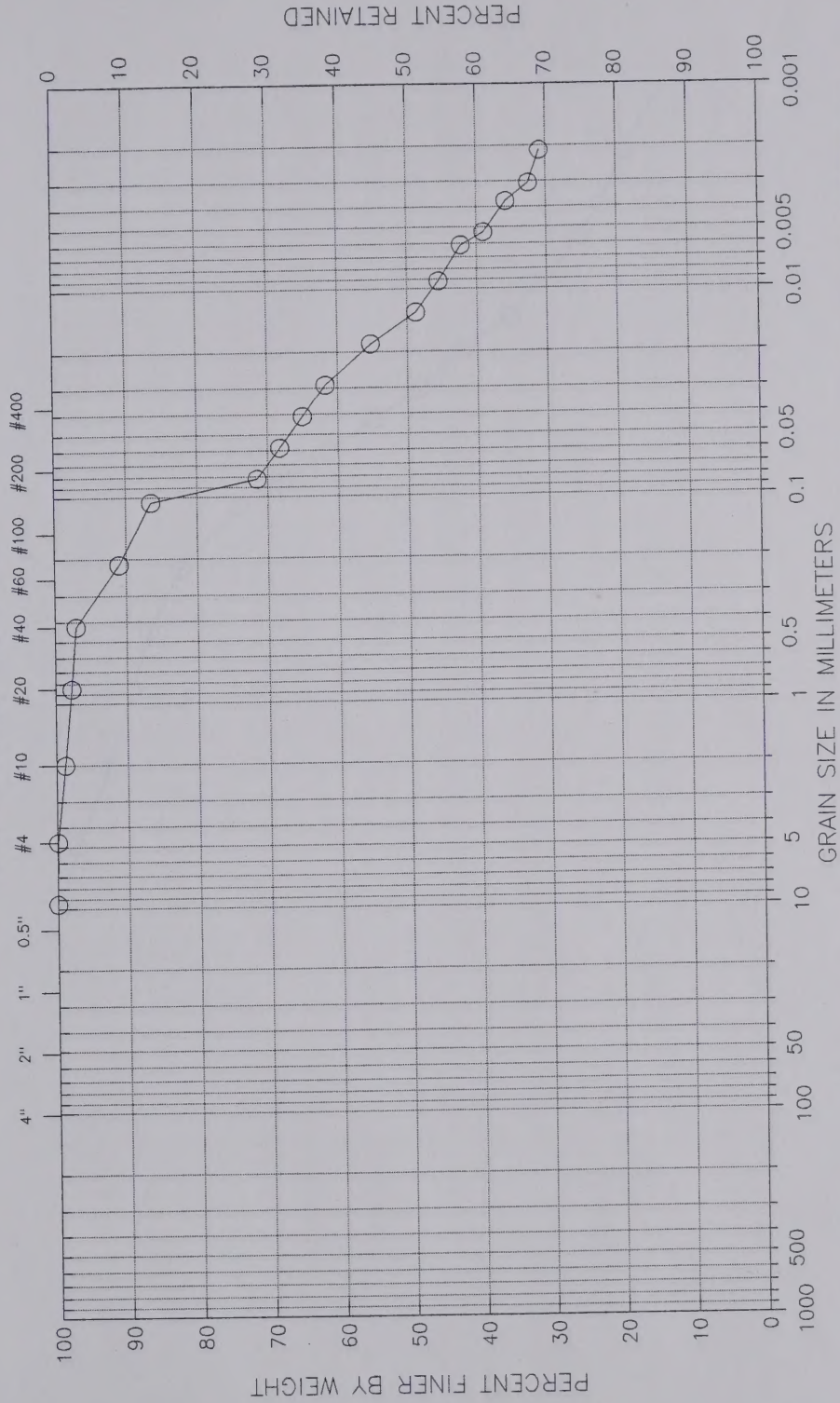


Fig. 2.5

Boring No.: MW-1
Sample No.: 1335A
Tested by : DCH/CHM
Filename : 1335A

Project : Mr. M Landfill
Project No.: 579-03
Location:
Date : Tue Jul 06 1993

U.S. STANDARD SIEVE SIZE



COBBLES	GRAVEL		SAND		SILT OR CLAY
	COARSE	FINE	COARSE	FINE	

Classification :

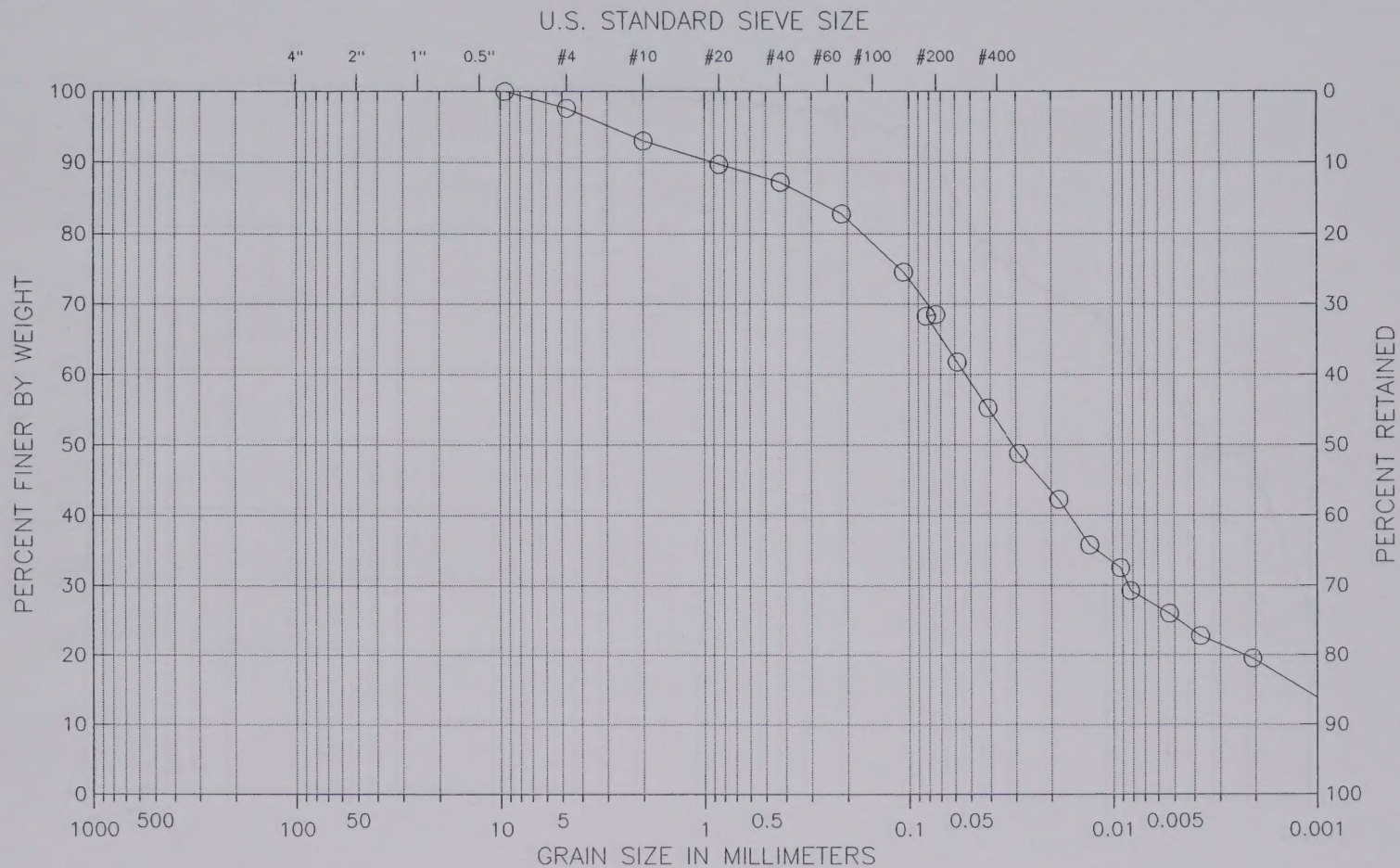
()

Visual Description :
Silty Clay (CL)

Remarks :
Depth: 5.0 - 6.5 feet Moisture Content: 12.1%

Boring No. : MW-2
 Sample No.: 1335C
 Tested by : DCH/CHM
 Filename : 1335C

Project : Mr. M Landfill
 Project No.: 579-03
 Location:
 Date : Tue Jul 06 1993



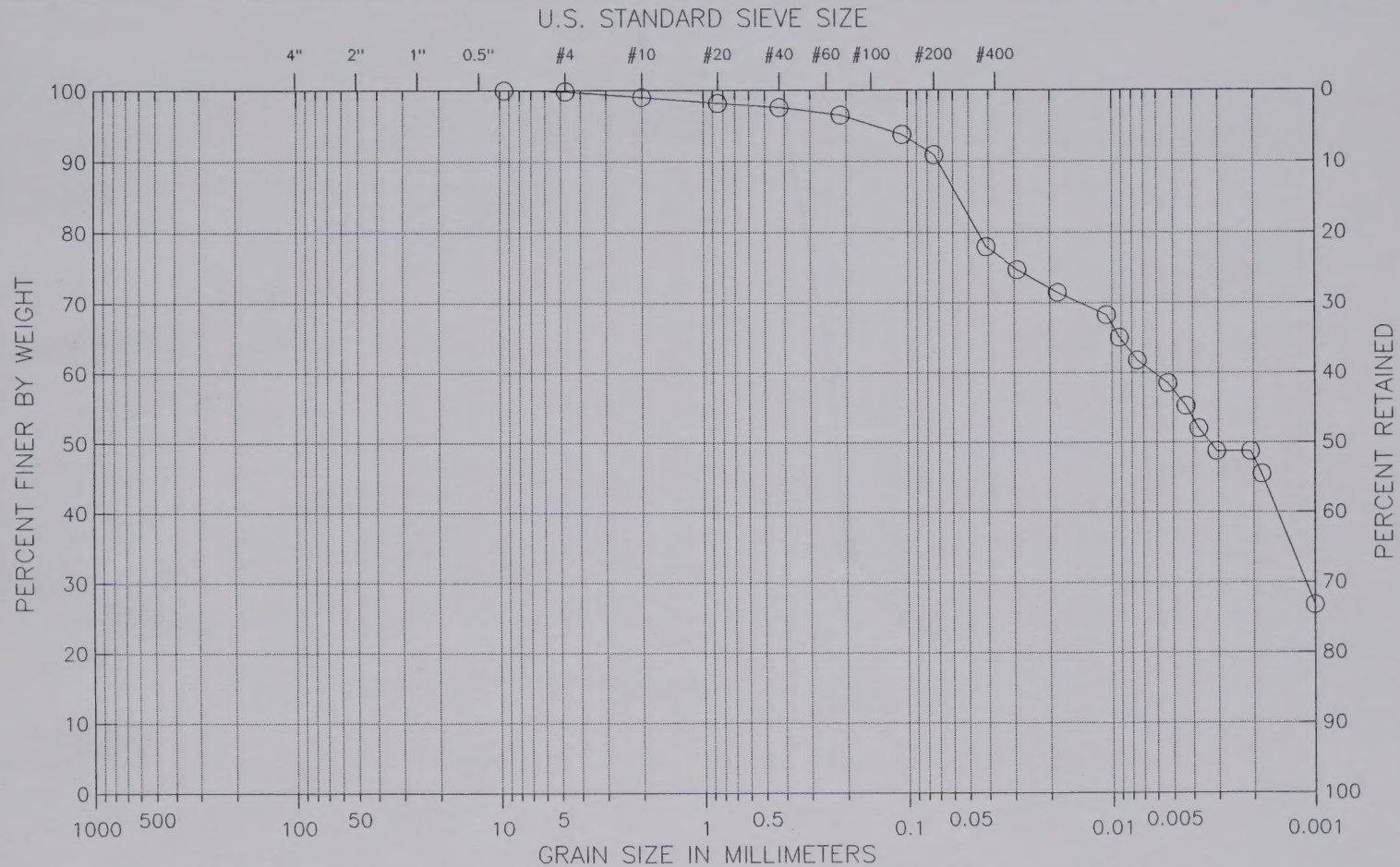
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Classification :
 (CL) Sandy lean clay
 Visual Description :
 Clayey Silt/Silty Clay (CL-ML)

Remarks :
 Depth: 4.0 - 5.5 feet Moisture Content: 11.5%

Boring No. : MW-3
Sample No.: 1335E
Tested by : DCH/CHM
Filename : 1335E

Project : Mr. M Landfill
Project No.: 579-03
Location:
Date : Tue Jul 06 1993



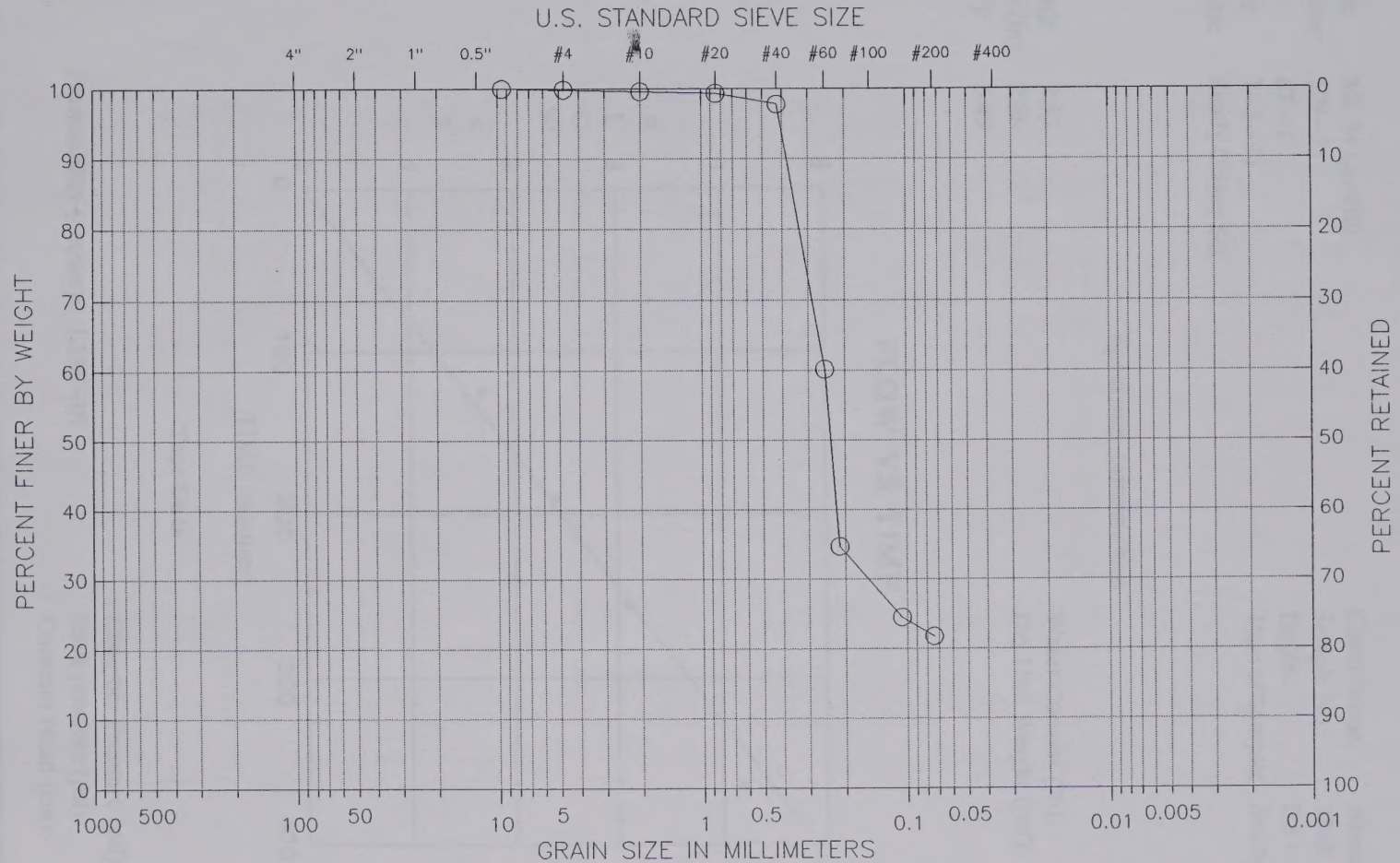
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Classification :
(CL) lean clay
Visual Description :
Clayey Silt/Silty Clay (CL)

Remarks :
Depth: 4.0 - 5.5 feet Moisture Content: 13.8%

Boring No. : MW-4
Sample No.: 1335F
Tested by : DCH/CHM
Filename : 1335F

Project : Mr. M Landfill
Project No.: 579-03
Location:
Date : Tue Jul 06 1993



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Classification :
()
Visual Description :
Clayey Silt/Silty Clay

Remarks :
Depth: 9.0 - 10.5 feet Moisture Content: 12.9%

PERMEABILITY TEST REPORT

Sample Information

Job Name: Mr. M Landfill
Job Number: 579-03
Location: ST-1
Test Date: 7-1-93
Description: Sandy Clayey Silt

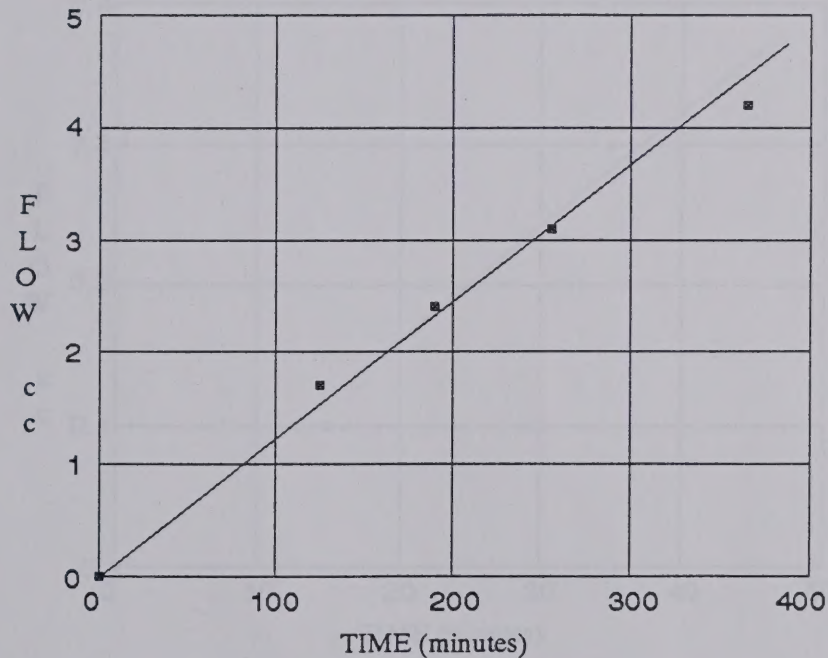
Client Name: Abenaki
Sample No.: 1342
Depth: 0.5 - 1.8 feet
Type of Sample: Shelby Tube

Specimen Information

Height (in): 2.63
Diameter (in): 2.88
Area (in²): 6.49

Water Content (%): 17.78
Dry Unit Weight (pcf): 83.71

FLOW VS TIME



Test Data

Permeability (cm/sec): $1.18\text{E}-07$

Chamber Pressure (psi): 60
Back pressure (psi): 50
Constant Head (cm): 280

ABENAKI GEOENVIRONMENTAL, INC.
P.O. Box 1018
Lewistown, Montana 59457

PERMEABILITY TEST REPORT

Sample Information

Job Name: Mr. M Landfill
Job Number: 579-03
Location: ST-2
Test Date: 6-30-93
Description: Clayey Silt/Silty Clay

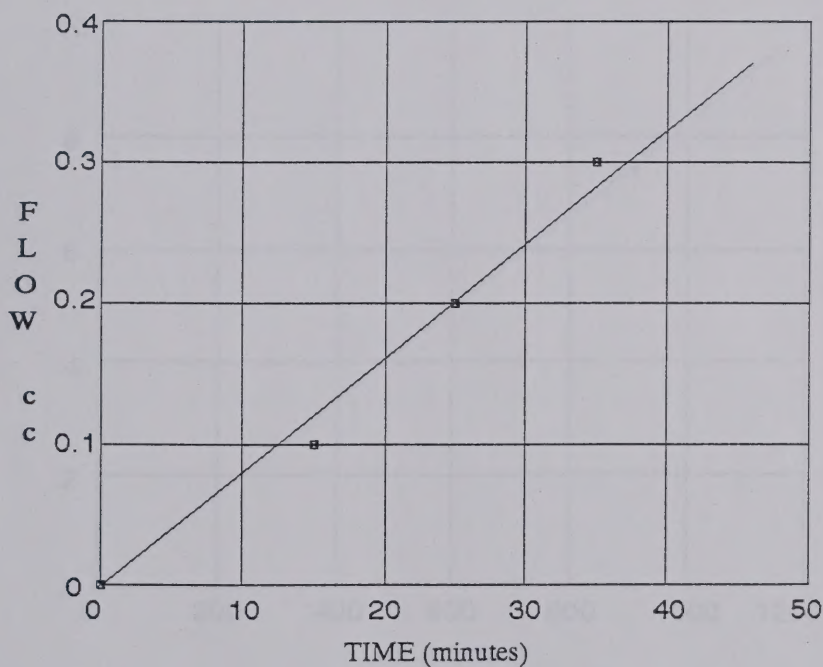
Client Name: Abenaki
Sample No.: 1343
Depth: 0.0 - 1.5 feet
Type of Sample: Shelby Tube

Specimen Information

Height (in): 3.75
Diameter (in): 2.88
Area (in²): 6.49

Water Content (%): 13.89
Dry Unit Weight (pcf): 115.30

FLOW VS TIME



Test Data

Permeability (cm/sec): $1.16E-07$

Chamber Pressure (psi): 60
Back pressure (psi): 50
Constant Head (cm): 280

ABENAKI GEOENVIRONMENTAL, INC.

P.O. Box 1018
Lewistown, Montana 59457

PERMEABILITY TEST REPORT

Sample Information

Job Name: Mr. M Landfill
Job Number: 579-03
Location: ST-3
Test Date: 7-2-93
Description: Clayey Silt/Silty Clay

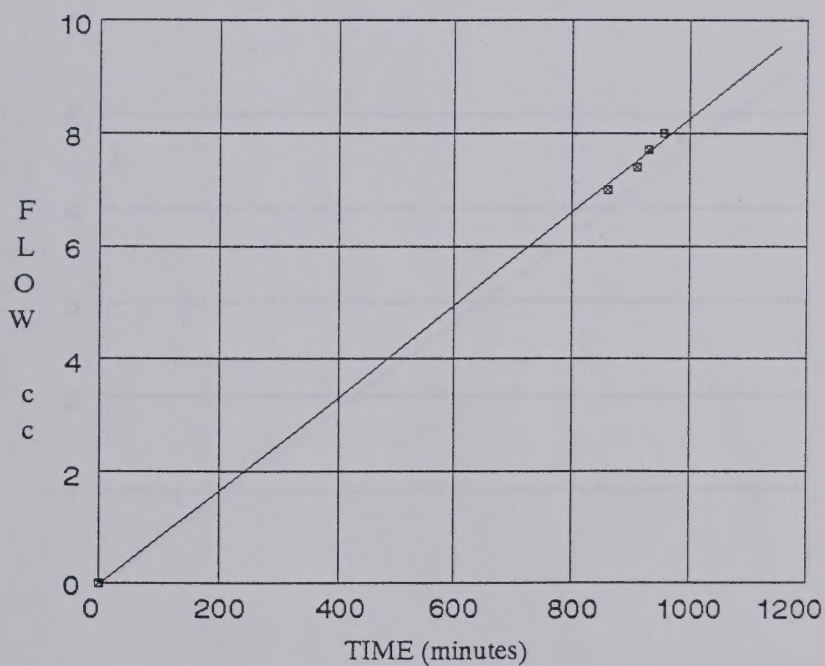
Client Name: Abenaki
Sample No.: 1344
Depth: 0.0 - 1.5 feet
Type of Sample: Shelby Tube

Specimen Information

Height (in): 5.13
Diameter (in): 2.88
Area (in²): 6.49

Water Content (%): 9.09
Dry Unit Weight (pcf): 111.62

FLOW VS TIME



Test Data

Permeability (cm/sec): $1.52E-07$

Chamber Pressure (psi): 60
Back pressure (psi): 50
Constant Head (cm): 280

ABENAKI GEOENVIRONMENTAL, INC.
P.O. Box 1018
Lewistown, Montana 59457

PERMEABILITY TEST REPORT

Sample Information

Job Name: Mr. M Landfill
Job Number: 579-03
Location: ST-4
Test Date: 7-2-93
Description: Clayey Silt/Silty Clay

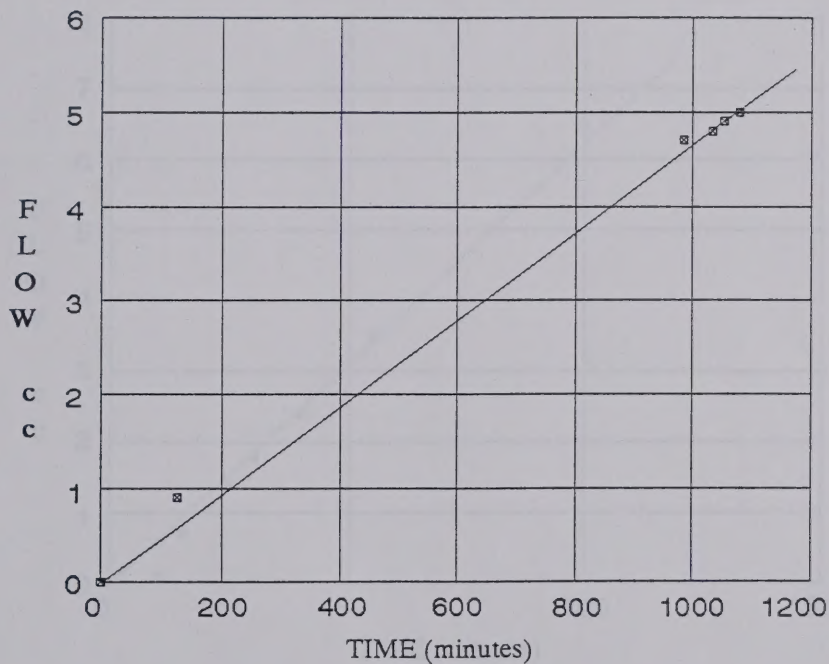
Client Name: Abenaki
Sample No.: 1345
Depth: 0-1.6 Feet
Type of Sample: Shelby Tube

Specimen Information

Height (in): 3.13
Diameter (in): 2.88
Area (in²): 6.49

Water Content (%): 10.66
Dry Unit Weight (pcf): 132.90

FLOW VS TIME



Test Data

Permeability (cm/sec): $5.84E-08$

Chamber Pressure (psi): 60
Back pressure (psi): 50
Constant Head (cm): 280

ABENAKI GEOENVIRONMENTAL, INC.
P.O. Box 1018
Lewistown, Montana 59457

PERMEABILITY TEST REPORT

Sample Information

Job Name: Mr. M Landfill
Job Number: 579-03
Location: ST-5
Test Date: 6-29-93
Description: Clayey Silt/Silty Clay

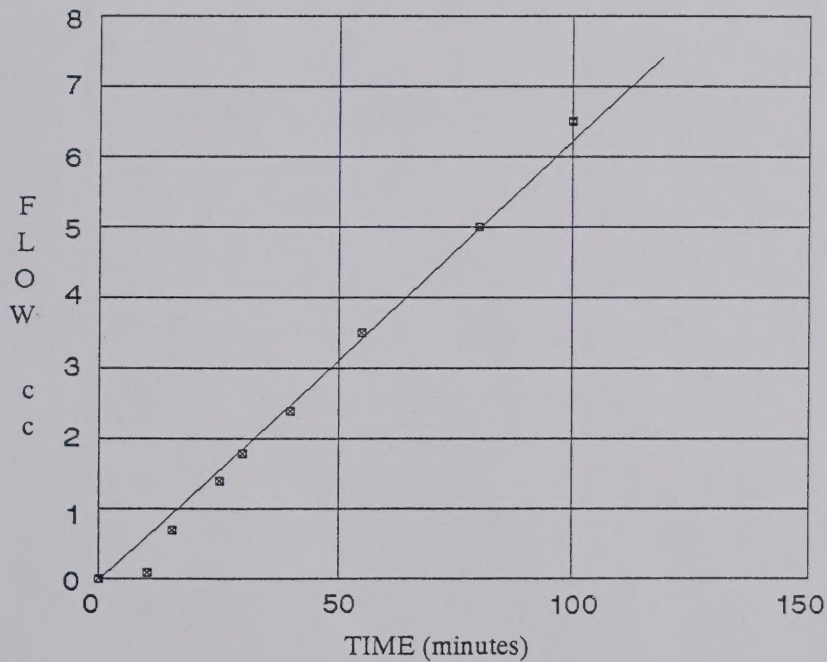
Client Name: Abenaki
Sample No.: 1346
Depth: 0.0 - 1.4 feet
Type of Sample: Shelby Tube

Specimen Information

Height (in): 2.88
Diameter (in): 3.25
Area (in²): 8.30

Water Content (%): 16.43
Dry Unit Weight (pcf): 89.90

FLOW VS TIME



Test Data

Permeability (cm/sec): $4.30E-07$

Chamber Pressure (psi): 60
Back pressure (psi): 50
Constant Head (cm): 280

ABENAKI GEOENVIRONMENTAL, INC.
P.O. Box 1018
Lewistown, Montana 59457

APPENDIX A

TEST BORING LOGS

MONITORING WELL PROFILES

AND

TEST PIT LOGS

TEST BORING LOG MW-1

Project: Mister M Landfill
Location: Lewistown, Montana
Client: Mister M, Inc.

Approximate Surface Elevation: 4169.8
Ground Water Depth: NFGWE
Date: 6-16-93

Project No. 579-03

Sheet No. 1 of 14

DEPTH, FT.	SYMBOL	SAMPLES	SAMPLE #	DESCRIPTION OF MATERIAL	SAMPLE RECOVERY, IN.	BLOWS PER 6"	SPT-N BLOWS PER FT.	MOISTURE CONTENT, %
0	✓✓✓✓			Topsoil and Organic Material				
				CLAY; very stiff, damp, moderate plasticity index, trace sand, red-brown, (Weathered SHALE).				
5			S-1		16	6 10 9	19	
10			S-2	Becoming less clayey, yellow-brown, oxidation zones below 8+/- ft., becoming reddish again at 15+/- ft.	18	6 6 8	14	
15								
20								
25				Refusal with auger (SHALE).				
30								

TEST BORING LOG MW-2

Project: Mister M Landfill
Location: Lewistown, Montana
Client: Mister M, Inc.

Approximate Surface Elevation: 4194.6
Ground Water Depth: NFGWE
Date: 6-16-93

Project No. 579-03

Sheet No. 2 of 14

DEPTH, FT.	SYMBOL	SAMPLES	SAMPLE #	DESCRIPTION OF MATERIAL	SAMPLE RECOVERY, IN.	BLOWS PER 6"	SPT-N BLOWS PER FT.	MOISTURE CONTENT, %
0				Topsoil and Organic Material				
				FILL; sandy clay, firm, moist, gray-brown with yellow brown streaks.				
5			S-1		17	4 5 4	9	
10			No number?		17	3 3 4	7	
				CLAY; firm, moist, red. Turning tan at 18 ft., highly bentonitic, (weathered SHALE with BENTONITE).				
15								
20								
25				Bottom of Hole.				
30								

TEST BORING LOG MW-3

Project: Mister M Landfill
Location: Lewistown, Montana
Client: Mister M, Inc.

Approximate Surface Elevation: 4205
Ground Water Depth: NFGWE
Date: 6-16-93

Project No. 579-03

Sheet No. 3 of 14

DEPTH, FT.	SYMBOL	SAMPLES	SAMPLE #	DESCRIPTION OF MATERIAL	SAMPLE RECOVERY, IN.	BLOWS PER 6"	SPT-N BLOWS PER FT.	MOISTURE CONTENT, %
0				CLAY; soft to firm, wet to moist, plastic, gray.				
5			S-1	CLAY (weathered shale); stiff to hard, damp, plastic, red-maroon.	14	7 12 14	26	
10			S-2	(Red beds) Becoming more silty with depth, SILTSTONE, maroon-gray to light gray, return to maroon SHALE at 8 ft.	18	10 23 33	56	
15								
20								
25								
30				Auger Refusal (SHALE).				

TEST BORING LOG MW-4

Project: Mister M Landfill
Location: Lewistown, Montana
Client: Mister M, Inc.

Approximate Surface Elevation: 4195.8
Ground Water Depth: NFGWE
Date: 6-16-93

Project No. 579-03

Sheet No. 4 of 14

DEPTH, FT.	SYMBOL	SAMPLES	SAMPLE #	DESCRIPTION OF MATERIAL	SAMPLE RECOVERY, IN.	BLOWS PER 6"	SPT-N BLOWS PER FT.	MOISTURE CONTENT, %
0				SILTSTONE(?); soft, damp, fine, poorly graded, few SANDSTONE fragments, tan.				
5			S-1	Grading finer with depth, increasing plasticity, occasional thin hard zones, becoming moist.	18	4 4 5	9	
10			S-2		18	4 7 10	17	
15			S-3	SHALE; soft, damp, maroon to gray.	18	4 14 26	40	
20				Bottom of Hole.				
25								
30								

TEST BORING LOG MW-5

Project: Mister M Landfill
Location: Lewistown, Montana
Client: Mister M, Inc.

Approximate Surface Elevation: 4265.6
Ground Water Depth: NFGWE
Date: 6-19-93

Project No. 579-03

Sheet No. 5 of 14

DEPTH, FT.	SYMBOL	SAMPLES	SAMPLE #	DESCRIPTION OF MATERIAL	SAMPLE RECOVERY, IN.	BLOWS PER 6"	SPT-N BLOWS PER FT.	MOISTURE CONTENT, %
0				SHALE; red.				
5				SILTSTONE/SANDSTONE; gray-white, Tan at 9'.				
10				SANDSTONE; damp at 15', tan-white.				
15				SHALE; red-maroon.				
20				SANDSTONE; tan.				
25				SHALE; red.				
30				SILTSTONE; tan-yellow, some fine sand.				

TEST BORING LOG MW-5

Project: Mister M Landfill
Location: Lewistown, Montana
Client: Mister M, Inc.

Approximate Surface Elevation: 4265.6
Ground Water Depth: NFGWE
Date: 6-19-93

Project No. 579-03

Sheet No. 6 of 14

DEPTH, FT.	SYMBOL	SAMPLES	SAMPLE #	DESCRIPTION OF MATERIAL	SAMPLE RECOVERY, IN.	BLOWS PER 6"	SPT-N BLOWS PER FT.	MOISTURE CONTENT, %
35				May grade to silty SANDSTONE, hard at 38.0'.				
40				SHALE; thin gray SHALEY SILTSTONE beds, red.				
45				SANDSTONE; gray-white, hard. (3)				
				SHALE; red.				
50				SANDSTONE; (hard) (4)				
				SHALE; alternating-hard zones, very hard at 56.0', red.				
55								
60				SANDSTONE; gray-white, hard. (5)				
65				SHALE; hard, SHALE becoming softer with depth, red. (SANDSTONE at 64'-65'; hard zone at 69'.)				

TEST BORING LOG MW-5

Project: Mister M Landfill
Location: Lewistown, Montana
Client: Mister M, Inc.

Approximate Surface Elevation: 4265.6
Ground Water Depth: NFGWE
Date: 6-19-93

Project No. 579-03

Sheet No. 7 of 14

DEPTH, FT.	SYMBOL	SAMPLES	SAMPLE #	DESCRIPTION OF MATERIAL	SAMPLE RECOVERY, IN.	BLOWS PER 6"	SPT-N BLOWS PER FT.	MOISTURE CONTENT, %
70				SANDSTONE; very hard, gray-white, dry. ⑥				
75				SHALE; red.				
80				SHALE; gray, slight sand content.				
85				SHALE; soft, easy drilling, becoming harder with depth, gray seams, red.				
90				SANDSTONE; gray. ⑦				
95				SHALE; hard, red-gray.				
100				Hard SILTSTONE seam at 100'-101', thin hard zones.				

TEST BORING LOG MW-5

Project: Mister M Landfill
 Location: Lewistown, Montana
 Client: Mister M, Inc.

Approximate Surface Elevation: 4265.6
 Ground Water Depth: NFGWE
 Date: 6-19-93

Project No. 579-03

Sheet No. 8 of 14

DEPTH, FT.	SYMBOL	SAMPLES	SAMPLE #	DESCRIPTION OF MATERIAL	SAMPLE RECOVERY, IN.	BLOWS PER 6"	SPT-N BLOWS PER FT.	MOISTURE CONTENT, %
105				Hard light gray SHALE or SHALEY SILTSTONE at 106'.				
110								
115				Bottom of Hole.				
120								
125								
130								
135								

TEST BORING LOG MW-6

Project: Mister M Landfill
Location: Lewistown, Montana
Client: Mister M, Inc.

Approximate Surface Elevation: 4263.0
Ground Water Depth: NFGWE
Date: 6-19-93

Project No. 579-03

Sheet No. 9 of 14

DEPTH, FT.	SYMBOL	SAMPLES	SAMPLE #	DESCRIPTION OF MATERIAL	SAMPLE RECOVERY, IN.	BLOWS PER 6"	SPT-N BLOWS PER FT.	MOISTURE CONTENT, %
0				SANDSTONE; weakly cemented, tan to brown, moist at 20'. ①				
5								
10				Very thin gray SHALE interbeds.				
15								
20								
25								
30				SHALE; soft, red-maroon.				
				SILTSTONE; sandy, soft, gray to tan.				

TEST BORING LOG MW-6

Project: Mister M Landfill
Location: Lewistown, Montana
Client: Mister M, Inc.

Approximate Surface Elevation: 4263.0
Ground Water Depth: NFGWE
Date: 6-19-93

Project No. 579-03

Sheet No. 10 of 14

DEPTH, FT.	SYMBOL	SAMPLES	SAMPLE #	DESCRIPTION OF MATERIAL	SAMPLE RECOVERY, IN.	BLOWS PER 6"	SPT-N BLOWS PER FT.	MOISTURE CONTENT, %
35				Very hard from 36.5 - 38 ft.				
40				SHALE; soft, maroon, grayish with depth.				
45				SHALE; hard, red to red-gray.				
50				SANDSTONE; hard, gray to tan. <i>2nd</i>				
55				Becoming SHALEY with depth, trace red.				
60				SILTSTONE; sandy, soft, grading to SILTY SANDSTONE. <i>3rd</i> Becoming SHALEY with depth.				
65				SHALEY SANDSTONE; very hard, less shaley and hard with depth, 71' - 81' very hard SANDSTONE. <i>4th</i>				

TEST BORING LOG MW-6

Project: Mister M Landfill
Location: Lewistown, Montana
Client: Mister M, Inc.

Approximate Surface Elevation: 4263.0
Ground Water Depth: NFGWE
Date: 6-19-93

Project No. 579-03

Sheet No. 11 of 14

DEPTH, FT.	SYMBOL	SAMPLES	SAMPLE #	DESCRIPTION OF MATERIAL	SAMPLE RECOVERY, IN.	BLOWS PER 6"	SPT-N BLOWS PER FT.	MOISTURE CONTENT, %
70								
75								
80								
				SHALE; red, becoming grayish then tan-gray then red-gray, hard at 86'.				
85								
90								
				SANDSTONE; hard, shaley in thin seams, becoming damp.				
95								
100								

TEST BORING LOG MW-6

Project: Mister M Landfill
Location: Lewistown, Montana
Client: Mister M, Inc.

Approximate Surface Elevation: 4263.0
Ground Water Depth: NFGWE
Date: 6-19-93

Project No. 579-03

Sheet No. 12 of 14

DEPTH, FT.	SYMBOL	SAMPLES	SAMPLE #	DESCRIPTION OF MATERIAL	SAMPLE RECOVERY, IN.	BLOWS PER 6"	SPT-N BLOWS PER FT.	MOISTURE CONTENT, %
105								
110				Bottom of Hole.				
115								
120								
125								
130								
135								

TEST BORING LOG MW-7

Project: Mister M Landfill
Location: Lewistown, Montana
Client: Mister M, Inc.

Approximate Surface Elevation: 7
Ground Water Depth: NFGWE
Date: 6-19-93

Project No. 579-03

Sheet No. 13 of 14

DEPTH, FT.	SYMBOL	SAMPLES	SAMPLE #	DESCRIPTION OF MATERIAL	SAMPLE RECOVERY, IN.	BLOWS PER 6"	SPT-N BLOWS PER FT.	MOISTURE CONTENT, %
0				FILL, silty clay; firm, damp, gray to red-green.				
5				SHALE; weathered, moist, plastic, red.				
10				BENTONITIC SHALE with sandstone seams.				
15								
20								
25				SHALE; soft, red-maroon to red-gray, more maroon with depth.				
30								

TEST BORING LOG MW-8

Project: Mister M Landfill
Location: Lewistown, Montana
Client: Mister M, Inc.

Approximate Surface Elevation: 4169.6
Ground Water Depth: NFGWE
Date: 6-19-93

Project No. 579-03

Sheet No. 14 of 14

DEPTH, FT.	SYMBOL	SAMPLES	SAMPLE #	DESCRIPTION OF MATERIAL	SAMPLE RECOVERY, IN.	BLOWS PER 6"	SPT-N BLOWS PER FT.	MOISTURE CONTENT, %
0	<<<<<			Topsoil and Organic Material CLAY; stiff, damp, medium plasticity index, reddish-brown, grading lighter at 8 feet, more plastic below 15 ft.				
5	/ / / / /							
10	.							
15	.							
20	.							
25	.			Auger Refusal (SHALE).				
30	.							

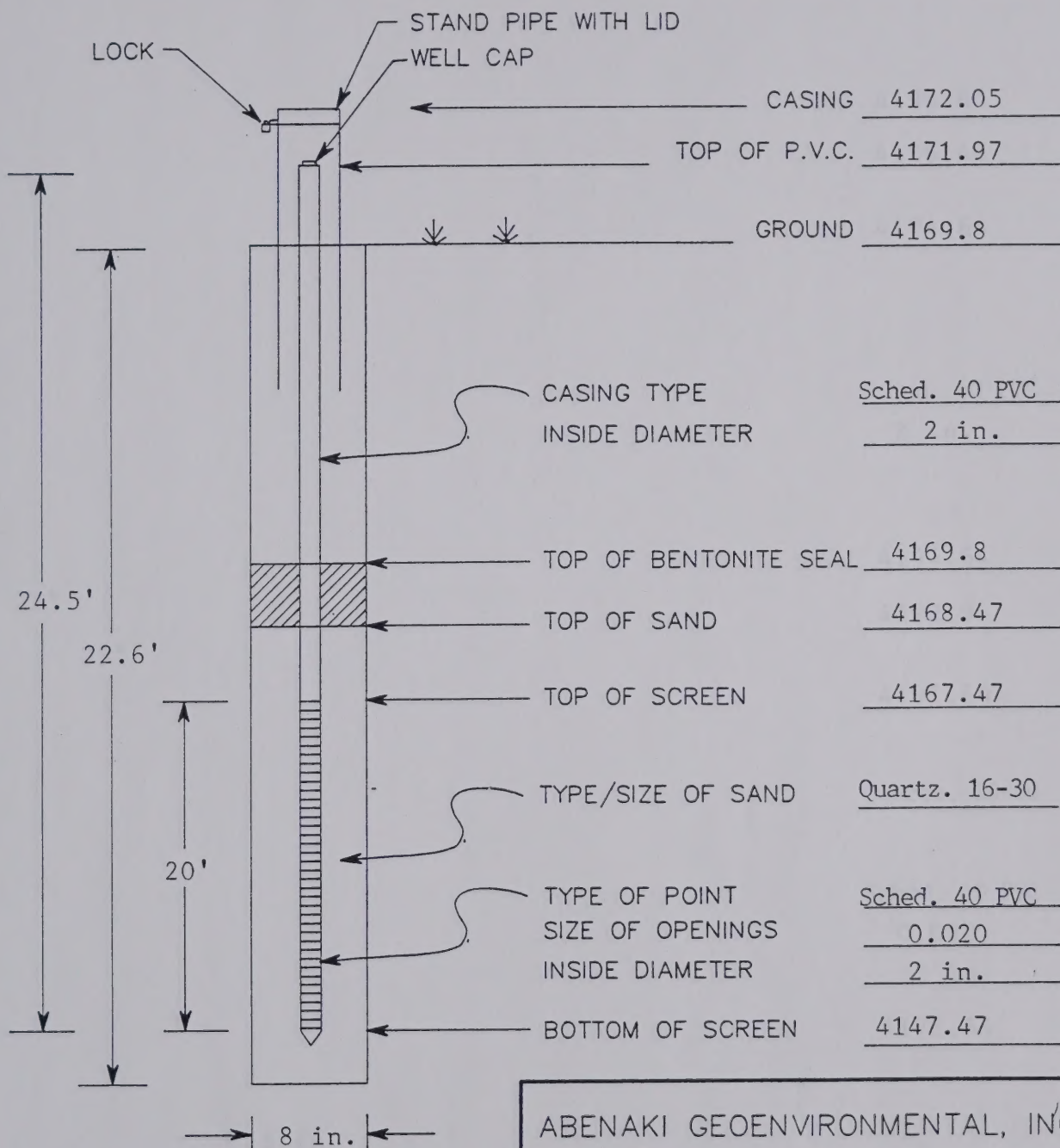
GROUND WATER OBSERVATION WELL COMPLETION PROFILE

WELL NO.: MW-1

OBSERVED WATER SURFACE ELEVATION: N/A

DATE: 6/93

DISTANCE BELOW GROUND: NFGWE



ABENAKI GEOENVIRONMENTAL, INC.

PROJECT: Mister M

PROJECT NO.: 579-03

LOCATION: Lewistown, MT

DRILLING DATE: 6-16-93

COMPLETION DATE: 6-16-93

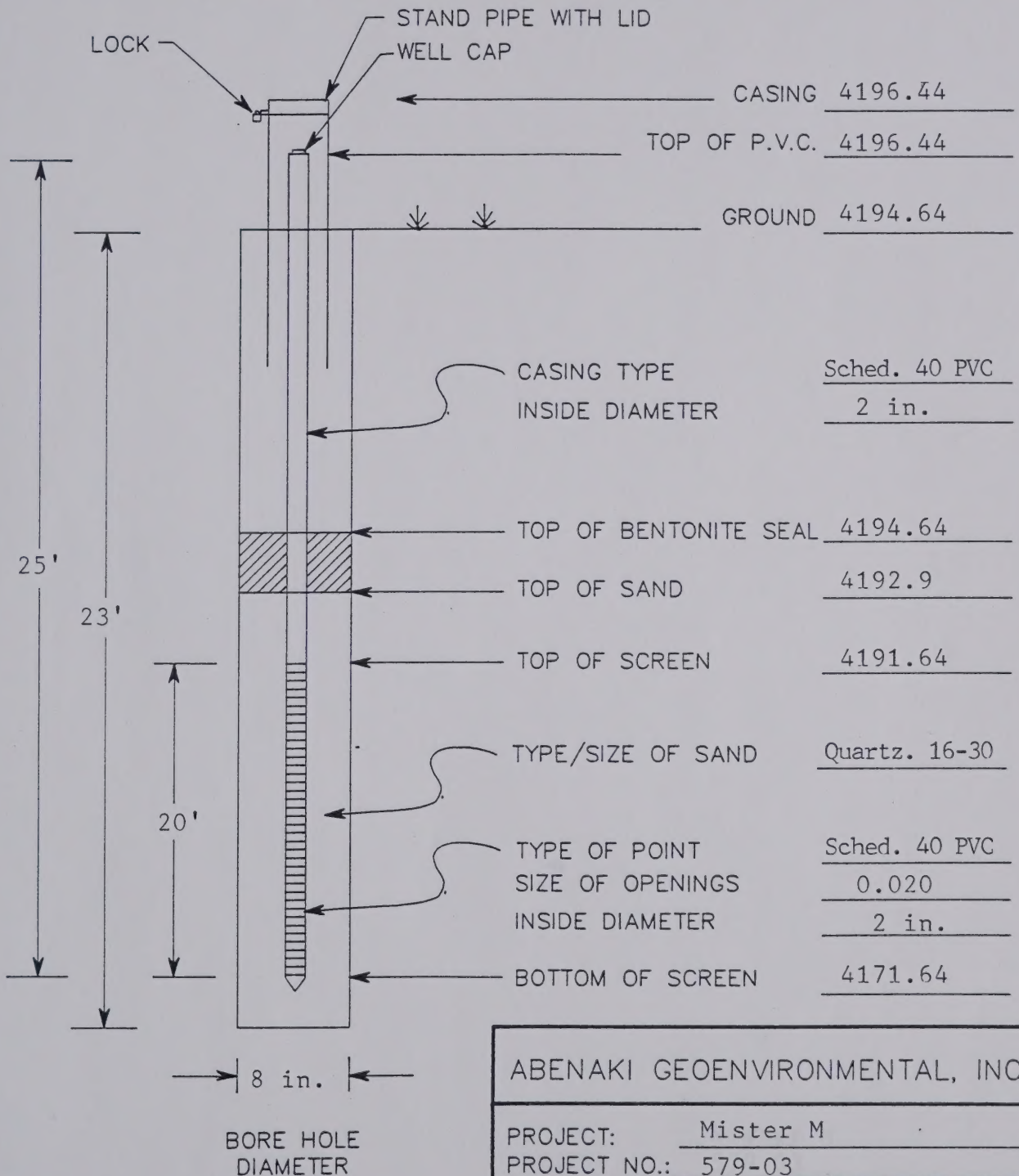
GROUND WATER OBSERVATION WELL COMPLETION PROFILE

WELL NO.: MW-2

OBSERVED WATER SURFACE ELEVATION: N/A

DATE: 6/93

DISTANCE BELOW GROUND: NFGWE



ABENAKI GEOENVIRONMENTAL, INC.

PROJECT: Mister M

PROJECT NO.: 579-03

LOCATION: Lewistown, MT

DRILLING DATE: 6-16-93

COMPLETION DATE: 6-16-93

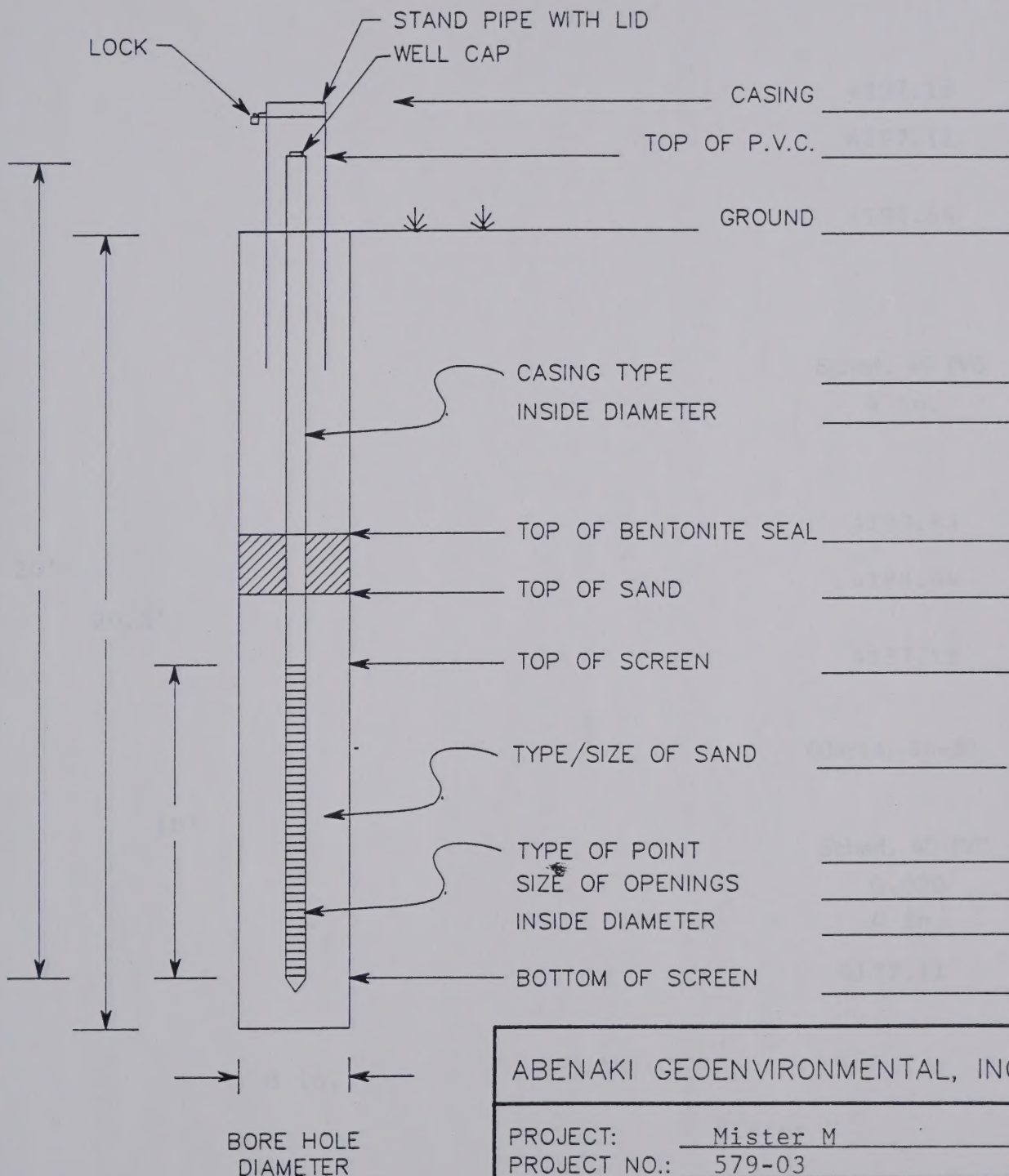
GROUND WATER OBSERVATION WELL COMPLETION PROFILE

WELL NO.: MW-3

OBSERVED WATER SURFACE ELEVATION: _____

DATE: 6/93

DISTANCE BELOW GROUND: _____



NOT INSTALLED
SEE BORING LOG

ABENAKI GEOENVIRONMENTAL, INC.

PROJECT: Mister M

PROJECT NO.: 579-03

LOCATION: Lewistown, MT

DRILLING DATE: 6-16-93

COMPLETION DATE: 6-16-93

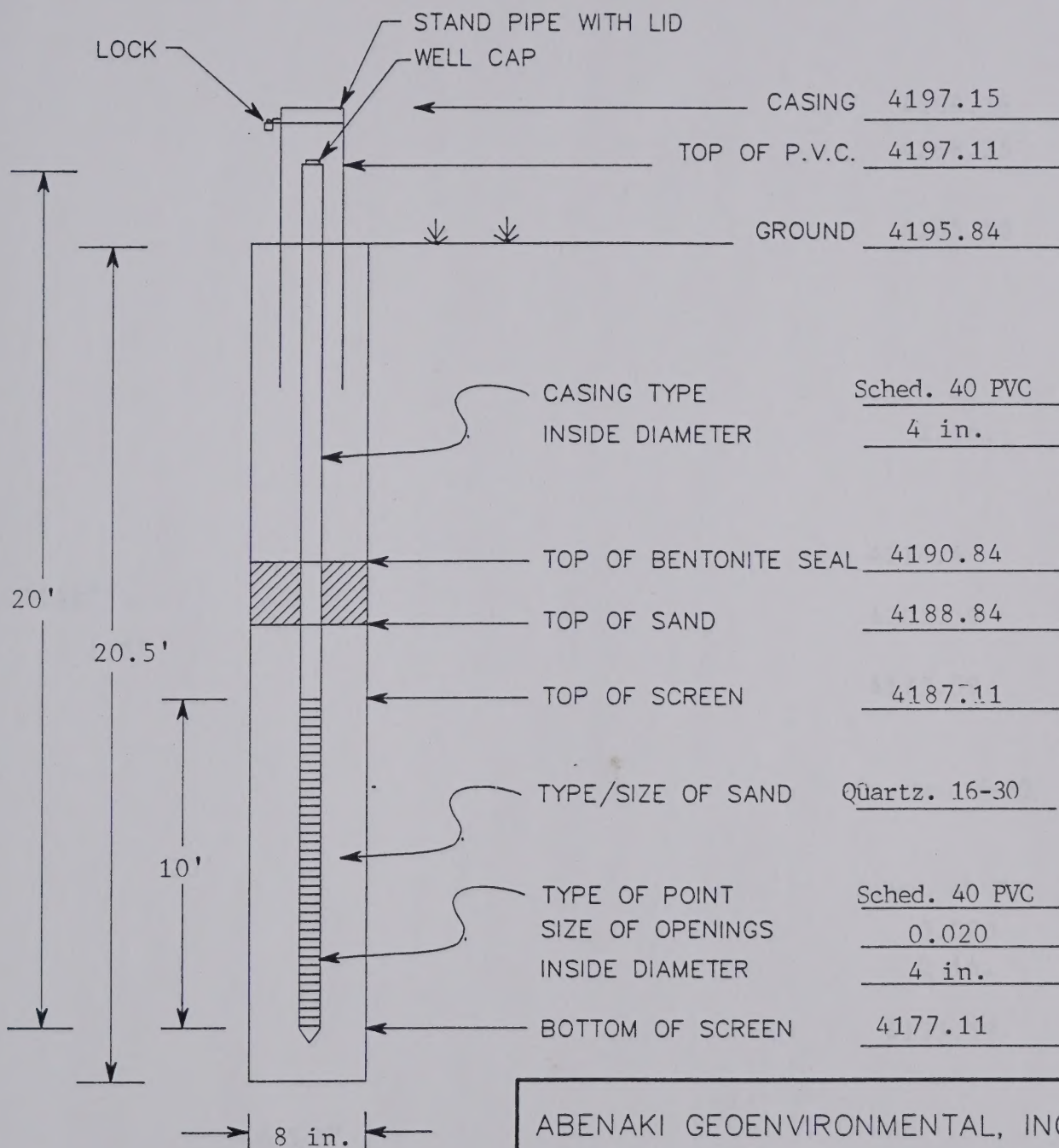
GROUND WATER OBSERVATION WELL COMPLETION PROFILE

WELL NO.: MW-4

OBSERVED WATER SURFACE ELEVATION: N/A

DATE: 6/93

DISTANCE BELOW GROUND: NFGWE



ABENAKI GEOENVIRONMENTAL, INC.

PROJECT: Mister M

PROJECT NO.: 579-03

LOCATION: Lewistown, MT

DRILLING DATE: 6-16-93

COMPLETION DATE: 6-16-93

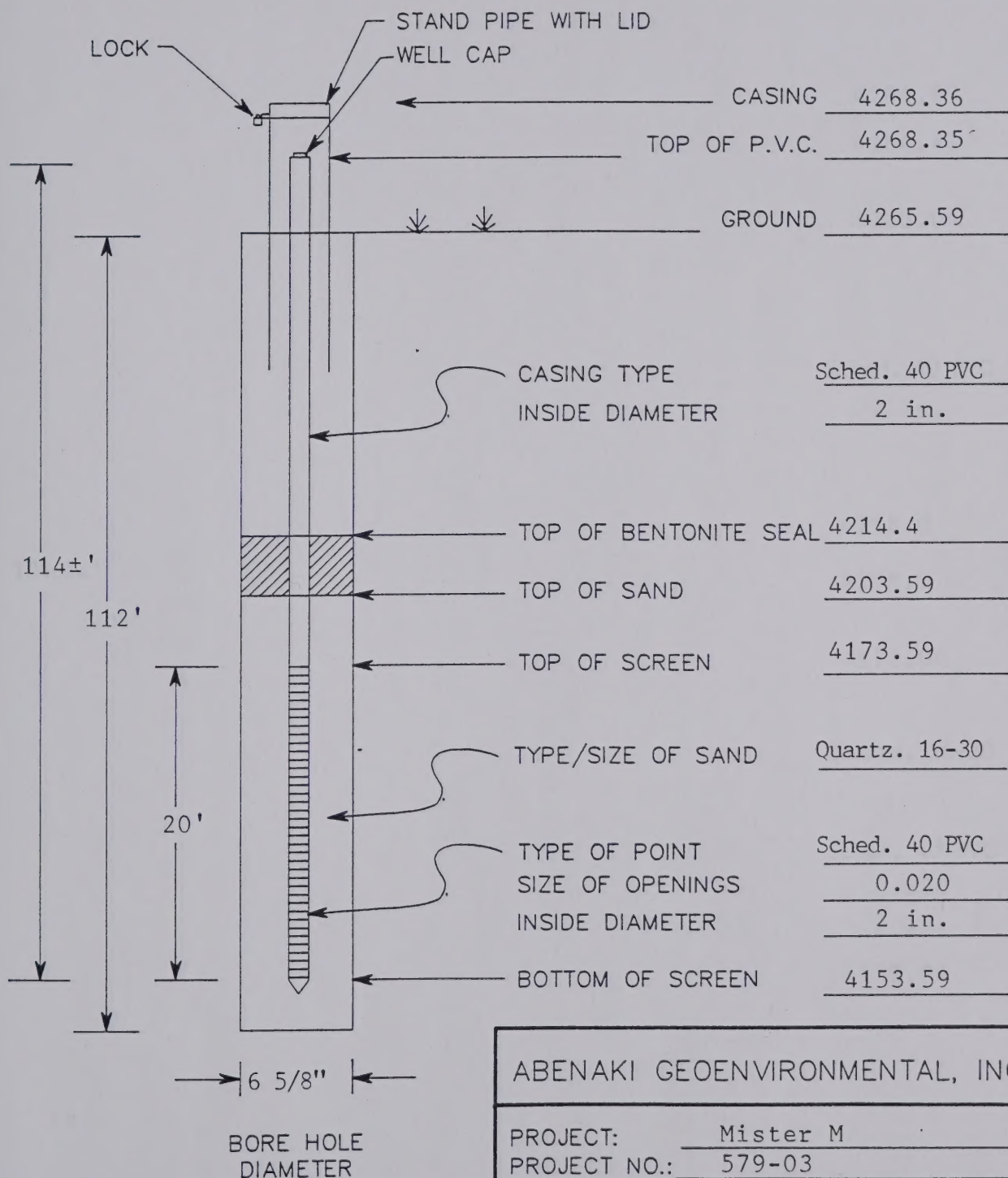
GROUND WATER OBSERVATION WELL COMPLETION PROFILE

WELL NO.: MW-5

OBSERVED WATER SURFACE ELEVATION: N/A

DATE: 6/93

DISTANCE BELOW GROUND: NFGWE



ABENAKI GEOENVIRONMENTAL, INC.

PROJECT: Mister M

PROJECT NO.: 579-03

LOCATION: Lewistown, MT

DRILLING DATE: 6-16-93

COMPLETION DATE: 6-16-93

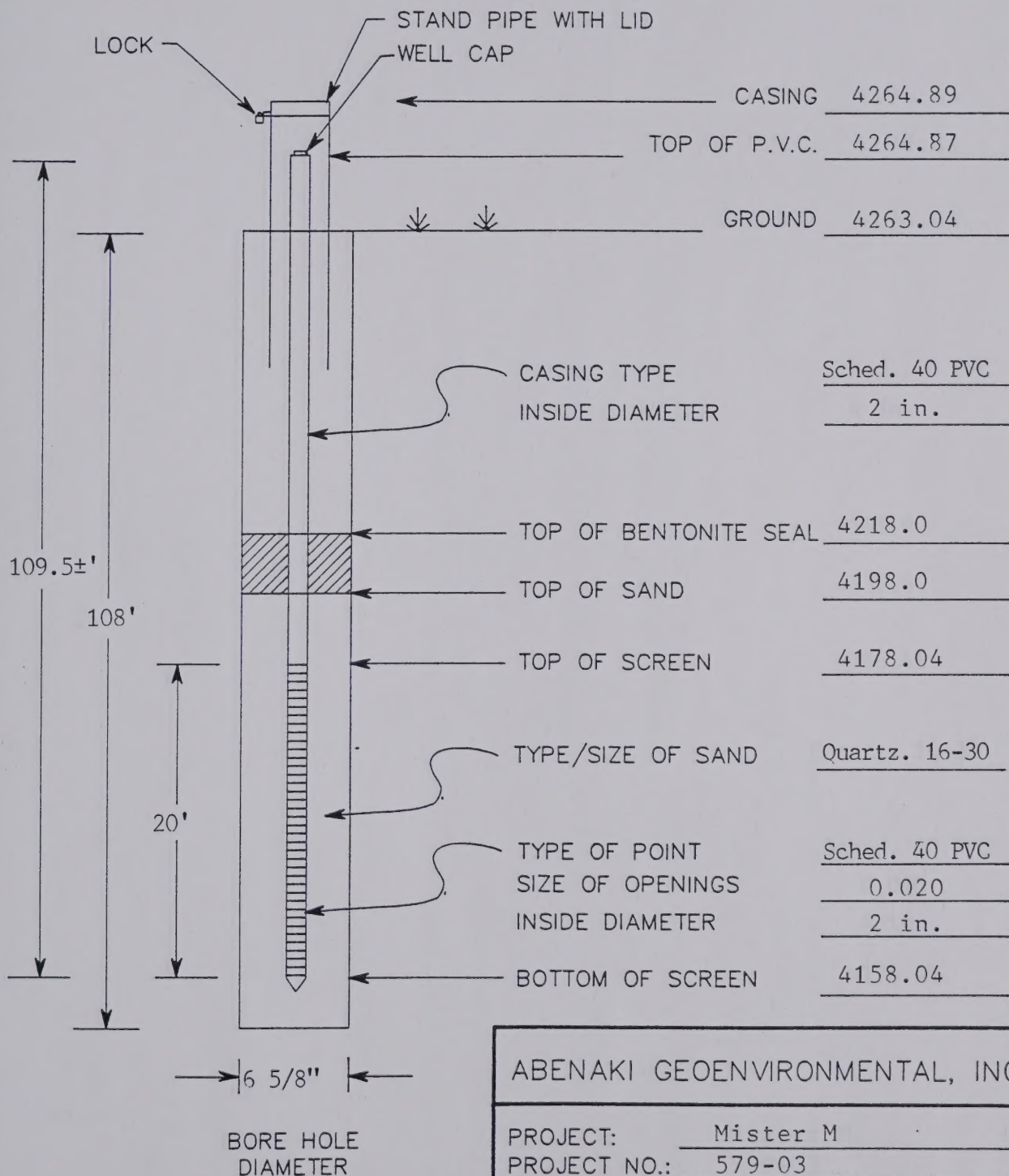
GROUND WATER OBSERVATION WELL COMPLETION PROFILE

WELL NO.: MW-6

OBSERVED WATER SURFACE ELEVATION: N/A

DATE: 6/93

DISTANCE BELOW GROUND: NFGWE



ABENAKI GEOENVIRONMENTAL, INC.

PROJECT: Mister M

PROJECT NO.: 579-03

LOCATION: Lewistown, MT

DRILLING DATE: 6-16-93

COMPLETION DATE: 6-16-93

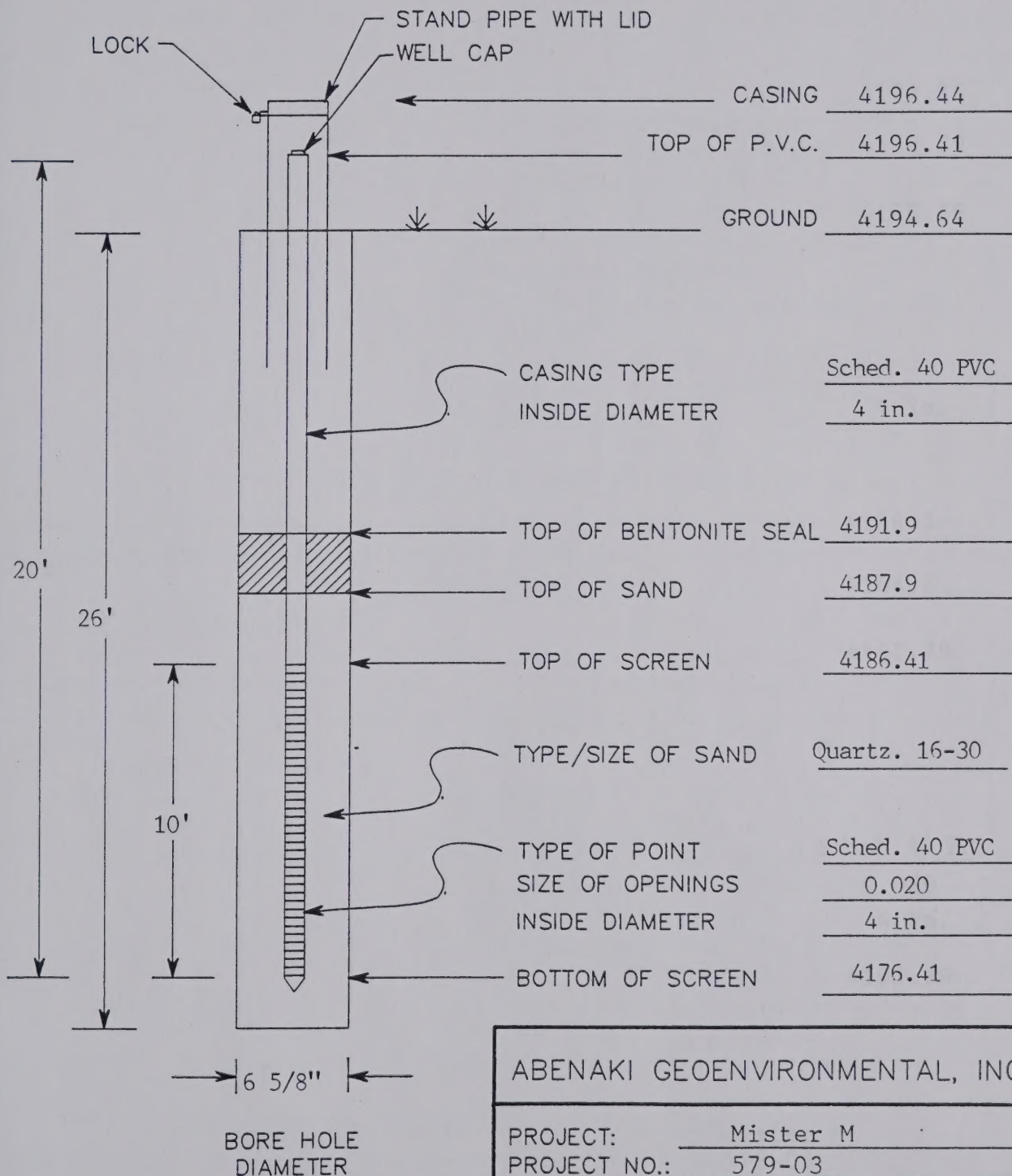
GROUND WATER OBSERVATION WELL COMPLETION PROFILE

WELL NO.: MW-7

OBSERVED WATER SURFACE ELEVATION: N/A

DATE: 6/93

DISTANCE BELOW GROUND: NFGWE



ABENAKI GEOENVIRONMENTAL, INC.

PROJECT: Mister M

PROJECT NO.: 579-03

LOCATION: Lewistown, MT

DRILLING DATE: 6-16-93

COMPLETION DATE: 6-16-93

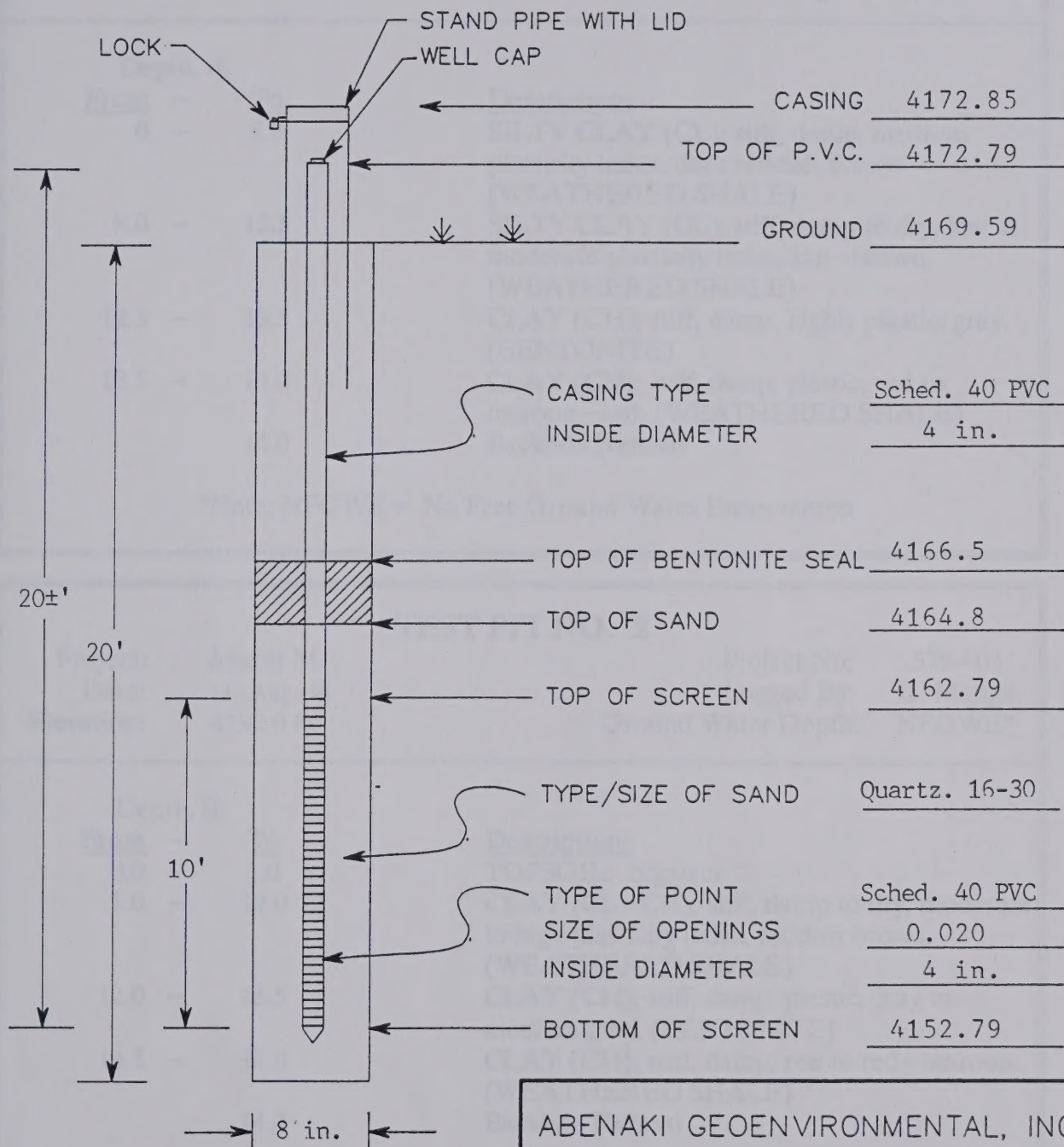
GROUND WATER OBSERVATION WELL COMPLETION PROFILE

WELL NO.: MW-8

OBSERVED WATER SURFACE ELEVATION: N/A

DATE: 6/93

DISTANCE BELOW GROUND: NFGWE



ABENAKI GEOENVIRONMENTAL, INC.

PROJECT: Mister M

PROJECT NO.: 579-03

LOCATION: Lewistown, MT

DRILLING DATE: 6-16-93

COMPLETION DATE: 6-16-93

TEST PIT NO. 1

Project: Mister M
Date: 14-Aug-93
Elevation: 4193.7 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.			<u>Description:</u>
<u>From</u>	-	<u>To</u>	
0	-	8.0	SILTY CLAY (CL); stiff, damp, medium plasticity index, dark reddish brown. (WEATHERED SHALE)
8.0	-	12.5	SILTY CLAY (CL); stiff, damp to dry, low to moderate plasticity index, tan-brown. (WEATHERED SHALE)
12.5	-	13.5	CLAY (CH); stiff, damp, highly plastic, gray. (BENTONITE)
13.5	-	14.0	CLAY (CH); stiff, damp, plastic, red to maroon-red. (WEATHERED SHALE)
		14.0	Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

TEST PIT NO. 2

Project: Mister M
Date: 14-Aug-93
Elevation: 4192.0 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.			<u>Description:</u>
<u>From</u>	-	<u>To</u>	
0.0	-	1.0	TOPSOIL; organics
1.0	-	12.0	CLAY (CL-CH); stiff, damp to dry, moderate to high plasticity index, reddish brown. (WEATHERED SHALE)
12.0	-	13.5	CLAY (CH); stiff, damp, plastic, gray to medium gray. (BENTONITE)
13.5	-	14.0	CLAY (CH); stiff, damp, red to red-maroon. (WEATHERED SHALE)
		14.0	Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

ABENAKI GEOENVIRONMENTAL, INC.

P. O. Box 1018
Lewistown, Montana 59457

TEST PIT NO. 3

Project: Mister M
Date: 14-Aug-93
Elevation: 4195.7 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.
From - To
0 - 1.5

Description:

CLAY (CL-CH); stiff, damp to dry, moderate to high plasticity index, reddish brown.

(WEATHERED SHALE)

1.5 - 4.5

SILTSTONE; weathered, sandy, fine grained, high plasticity index, clay matrix with gravel to cobble size fragments, tan to tan-gray.

4.5

Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

TEST PIT NO. 4

Project: Mister M
Date: 14-Aug-93
Elevation: 4215.8 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.
From - To
0 - 1.0

Description:

CLAY (CL-CH); stiff, damp to dry, moderate to high plasticity index, reddish brown.

(WEATHERED SHALE)

1.0 - 6.0

SILTSTONE; weathered, sandy, fine grained, high plasticity index, clay matrix with gravel to cobble size fragments, tan to tan-gray.

6.0

Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

ABENAKI GEOENVIRONMENTAL, INC.

P. O. Box 1018
Lewistown, Montana 59457

TEST PIT NO. 5

Project: Mister M
Date: 14-Aug-93
Elevation: 4225.6 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.		<u>Description:</u>
<u>From</u>	<u>To</u>	
0	1.0	FILL; clay, damp, reddish brown.
1.0	2.0	Landfill Debris
2.0	2.5	SILTSTONE; weathered, sandy, fine grained, high plasticity index, clay matrix with gravel to cobble size fragments, tan to tan-gray.
	2.5	Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

TEST PIT NO. 6

Project: Mister M
Date: 14-Aug-93
Elevation: 4234.5 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.		<u>Description:</u>
<u>From</u>	<u>To</u>	
0	1.0	FILL; silty clay, stiff, damp, brown.
1.0	2.0	Landfill Debris
2.0	3.0	SILTSTONE; weathered, sandy, fine grained, high plasticity index, clay matrix with gravel to cobble size fragments, tan to tan-gray.
	3.0	Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

ABENAKI GEOENVIRONMENTAL, INC.

P. O. Box 1018
Lewistown, Montana 59457

TEST PIT NO. 7

Project: Mister M
Date: 14-Aug-93
Elevation: 4247.7 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.	
<u>From</u>	<u>To</u>
0	0.3
0.3	1.5
	1.5

Description:
TOPSOIL; organics
SILTY CLAY (CL); very stiff, damp to dry,
moderate plasticity index, shale fragments
with depth, gray. (WEATHERED SHALE)
Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

TEST PIT NO. 8

Project: Mister M
Date: 14-Aug-93
Elevation: 4256.7 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.	
<u>From</u>	<u>To</u>
0	1.0
1.0	2.1
	2.1

Description:
CLAY (CL-CH); stiff, damp, moderate to
high plasticity index, reddish brown.
(WEATHERED SHALE)
SILTY CLAY (CL); stiff, dry, moderate
plasticity index, shale fragments with depth,
gray. (WEATHERED SHALE)
Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

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Lewistown, Montana 59457

TEST PIT NO. 9

Project: Mister M
Date: 14-Aug-93
Elevation: 4260.7 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.
From - To
0 - 2.5

Description:
SILTY CLAY (CL); stiff, damp, moderate plasticity index, very small shale fragments below 1 ft., gray. (WEATHERED SHALE)
Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

TEST PIT NO. 10

Project: Mister M
Date: 14-Aug-93
Elevation: 4260.6 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.
From - To
0 - 2.5

Description:
CLAY (CH); very stiff, damp to dry, high plasticity index, reddish brown.
(WEATHERED SHALE)

2.5 - 4.0

CLAY (CH); hard, dry, blocky, high plasticity index, dark bluish gray.

4.0

Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

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TEST PIT NO. 11

Project: Mister M
Date: 14-Aug-93
Elevation: 4265.5 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.			<u>Description:</u>
<u>From</u>	-	<u>To</u>	
0	-	1.0	CLAY (CH); very stiff, damp to moist, high plasticity index, dark gray. (WEATHERED SHALE)
1.0	-	2.5	CLAY (CL-CH); very stiff, damp, moderate to high plasticity index, reddish-brown. (WEATHERED SHALE)
2.5	-	5.1	CLAY (CH); very stiff to hard, damp to dry, high plasticity index, alternating red-gray bands. (WEATHERED SHALE)
		5.1	Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

TEST PIT NO. 12

Project: Mister M
Date: 14-Aug-93
Elevation: 4271.9 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.			<u>Description:</u>
<u>From</u>	-	<u>To</u>	
0	-	1.0	TOPSOIL; clay with organics.
1.0	-	11.5	SILTY CLAY (CL); stiff to hard, damp to dry, shale fragments with depth, gray. (WEATHERED SHALE)
		11.5	Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

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TEST PIT NO. 13

Project: Mister M
Date: 14-Aug-93
Elevation: 4202.0 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.
From - To
0 - 0.3

Description:

SILTY CLAY (CL); soft, damp, low to moderate plasticity index, gray.

(WEATHERED SHALE)

0.3 - 9.5

SILTY CLAY (CL); stiff to hard, damp to dry, moderate plasticity index, some high plasticity index zones, shale fragments below 8 ft., reddish brown. (WEATHERED SHALE)

9.5

Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

TEST PIT NO. 14

Project: Mister M
Date: 05-Aug-93
Elevation: 4206.5 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.
From - To
0 - 0.5

Description:

SILTY CLAY (CL); firm, damp to moist, moderate plasticity index, dark reddish brown. (WEATHERED SHALE)

0.5 - 5.5

SILTY CLAY (CL); stiff, damp, moderate plasticity index, thin bentonite seams (2± in. thick), reddish gray to dark blue-gray. (WEATHERED SHALE)

5.5

Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

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TEST PIT NO. 15

Project: Mister M
Date: 05-Aug-93
Elevation: 4210.5 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.
From - To
0 - 4.0

Description:
SILTY CLAY (CL); soft to stiff, wet to dry,
moderate plasticity index, some sand size
fragments, gray to reddish gray.
(WEATHERED SHALE)
Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

TEST PIT NO. 16

Project: Mister M
Date: 05-Aug-93
Elevation: 4214.9 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.
From - To
0 - 5.5

Description:
SILTY CLAY (CL); stiff, damp to dry, shale
fragments below 3.5 feet, moderate plasticity
index, gray to reddish gray.
(WEATHERED SHALE)
Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

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TEST PIT NO. 17

Project: Mister M
Date: 05-Aug-93
Elevation: 4230.8 ft.

Project No: 579-03
Logged By: G. Menge
Ground Water Depth: NFGWE*

Depth, ft.
From - To
0 - 1.0

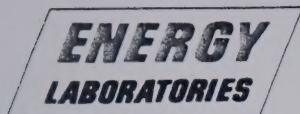
1.0

Description:
SILTY CLAY (CL); stiff, dry, moderate
plasticity index, trace sand, tan-gray.
(WEATHERED SHALE)
Backhoe Refusal

*Note: NFGWE = No Free Ground Water Encountered

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LABORATORY REPORT

TO: Becky Woolsey
ADDRESS: Abenaki Geoenvironmental
P.O. Box 1018
Lewistown, MT 59457

LAB NO.: 93-34807
DATE: 09/07/93 jmw

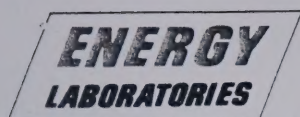
WATER ANALYSIS

Mr. M Disposal, Proj. #1044
Well #1
Sampled 08/10/93 @ 0930
Submitted 08/11/93

<u>Constituent</u>	<u>mg/l (ppm)</u>	<u>Date Analyzed</u>
Potassium	4	08/12/93
Sodium	12	08/12/93
Calcium	86	08/12/93
Magnesium	22	08/12/93
Sulfate	75	08/12/93
Chloride	16	08/12/93
Carbonate	0	08/12/93
Bicarbonate	315	08/12/93
Total Dissolved Solids @ 180°C	405	08/12/93
Total Alkalinity as CaCO ₃	258	08/12/93
Nitrate as N	0.77	08/13/93
Specific Conductance @ 25°C	544 μ mhos/cm	08/12/93
pH	7.5 s.u.	08/12/93
Ammonia as N	<0.1	08/13/93
Chemical Oxygen Demand	27	08/12/93
Total Suspended Solids	412	08/12/93

Dissolved Metals

Arsenic	<0.005	08/23/93
Barium	0.1	08/12/93
Cadmium	<0.001	08/17/93
Chromium	<0.01	08/12/93
Iron	<0.03	08/12/93
Lead	<0.01	08/13/93
Manganese	<0.01	08/12/93
Mercury	<0.001	08/12/93
Selenium	<0.005	08/13/93
Silver	<0.005	08/12/93

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LABORATORY REPORT

TO: Becky Woolsey
ADDRESS: Abenaki Geoenvironmental
P.O. Box 1018
Lewistown, MT 59457

LAB NO.: 93-34808
DATE: 09/07/93 jmw

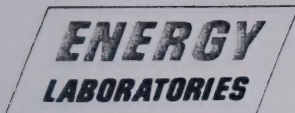
WATER ANALYSIS

Mr. M Disposal, Proj. #1044
Well #2
Sampled 08/10/93 @ 0940
Submitted 08/11/93

<u>Constituent</u>	<u>mg/l (ppm)</u>	<u>Date Analyzed</u>
Potassium	2	08/12/93
Sodium	21	08/12/93
Calcium	146	08/12/93
Magnesium	24	08/12/93
Sulfate	52	08/12/93
Chloride	47	08/12/93
Carbonate	0	08/26/93
Bicarbonate	356	08/26/93
Total Dissolved Solids @ 180°C	602	08/12/93
Total Alkalinity as CaCO ₃	291	08/26/93
Nitrate as N	<0.05	08/13/93
Specific Conductance @ 25°C	823 μ mhos/cm	08/12/93
pH	6.9 s.u.	08/26/93
Ammonia as N	<0.1	08/13/93
Chemical Oxygen Demand	57	08/12/93
Total Suspended Solids	3430	08/12/93

Dissolved Metals

Arsenic	<0.005	08/23/93
Barium	0.2	08/12/93
Cadmium	<0.001	08/13/93
Chromium	<0.01	08/12/93
Iron	<0.03	08/12/93
Lead	<0.01	08/13/93
Manganese	0.31	08/12/93
Mercury	<0.001	08/12/93
Selenium	<0.005	08/13/93
Silver	<0.005	08/12/93

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TO: Becky Woolsey
ADDRESS: Abenaki Geoenvironmental
P.O. Box 1018
Lewistown, MT 59457

LAB NO.: 93-34809
DATE: 09/07/93 jmw

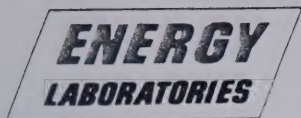
WATER ANALYSIS

Mr. M Disposal, Proj. #1044
Well #~~3~~4
Sampled 08/10/93 @ 0940
Submitted 08/11/93

<u>Constituent</u>	<u>mg/l (ppm)</u>	<u>Date Analyzed</u>
Potassium	3	08/31/93
Sodium	23	08/31/93
Calcium	85	08/31/93
Magnesium	20	08/31/93
Sulfate	51	08/24/93
Chloride	28	08/24/93
Carbonate	0	08/26/93
Bicarbonate	251	08/26/93
Total Dissolved Solids @ 180°C	498	08/12/93
Total Alkalinity as CaCO ₃	206	08/26/93
Nitrate as N	0.43	08/13/93
Specific Conductance @ 25°C	721 μ mhos/cm	08/12/93
pH	7.8 s.u.	08/26/93
Ammonia as N	<0.1	08/13/93
Chemical Oxygen Demand	40	08/12/93
Total Suspended Solids	16300	08/12/93

Dissolved Metals

Arsenic	<0.005	08/23/93
Barium	0.2	08/12/93
Cadmium	0.003	08/12/93
Chromium	<0.01	08/12/93
Iron	<0.01	08/12/93
Lead	0.03	08/12/93
Manganese	0.16	08/12/93
Mercury	<0.001	08/12/93
Selenium	<0.005	08/13/93
Silver	<0.005	08/12/93

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TO: Becky Woolsey
ADDRESS: Abenaki Geoenvironmental
P.O. Box 1018
Lewistown, MT 59457

LAB NO.: 93-34807
DATE: 08/31/93 da

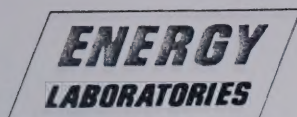
WATER ANALYSIS

Mr. M Disposal, Proj. #1044
Well #1
Sampled 08/10/93 @ 0930
Submitted 08/11/93
Analyzed 08/20/93

<u>Constituent</u>	<u>µg/l</u>	<u>Constituent</u>	<u>µg/l</u>
Benzene	< 1.0	1,1-Dichloroethane	< 1.0
Bromochloromethane	< 1.0	1,2-Dichloroethane	< 1.0
Bromodichloromethane	< 1.0	Iodomethane	< 1.0
cis-1,3-Dichloropropene	< 1.0	Methylene chloride	< 1.0
trans-1,3-Dichloropropene	< 1.0	1,1-Dichloroethene	< 1.0
1,4-Difluorobenzene	< 1.0	trans-1,2-Dichloroethene	< 1.0
Ethylbenzene	< 1.0	Styrene	< 1.0
Ethyl methacrylate	< 1.0	1,1,2,2-Tetrachloroethane	< 1.0
4-Bromofluorobenzene	< 10	Toluene	1.2
Bromoform	< 1.0	1,1,1-Trichloroethane	< 1.0 *
Bromomethane	< 1.0	1,1,2-Trichloroethane	< 1.0
Carbon tetrachloride	< 1.0	Trichloroethene	< 1.0
Chlorobenzene	< 1.0	Trichlorofluoromethane	< 1.0
Dibromochloromethane	< 1.0	1,2,3-Trichloropropane	< 1.0
Chloroethane	< 1.0	Vinyl acetate	< 1.0
2-Chloroethyl vinyl ether	< 1.0	Vinyl chloride	< 1.0
Chloroform	< 1.0	Xylenes	< 1.0
Chloromethane	< 1.0	Tetrachloroethene	< 1.0
Dibromomethane	< 1.0		
Dichlorodifluoromethane	< 1.0		

*Present but less than the practical quantitation limits.

NOTE: Analysis done by EPA method 8240.

**ENERGY LABORATORIES, INC.**

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LABORATORY REPORT

TO: Becky Woolsey
ADDRESS: Abenaki Geoenvironmental
P.O. Box 1018
Lewistown, MT 59457

LAB NO.: 93-34808
DATE: 08/31/93 da

WATER ANALYSIS

Mr. M Disposal, Proj. #1044

Well #2

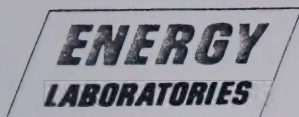
Sampled 08/10/93 @ 0940

Submitted 08/11/93

Analyzed 08/24/93

<u>Constituent</u>	<u>µg/l</u>	<u>Constituent</u>	<u>µg/l</u>
Benzene	< 1.0	1,1-Dichloroethane	< 1.0
Bromochloromethane	< 1.0	1,2-Dichloroethane	< 1.0
Bromodichloromethane	< 1.0	Iodomethane	< 1.0
cis-1,3-Dichloropropene	< 1.0	Methylene chloride	< 1.0
trans-1,3-Dichloropropene	< 1.0	1,1-Dichloroethene	< 1.0
1,4-Difluorobenzene	< 1.0	trans-1,2-Dichloroethene	< 1.0
Ethylbenzene	< 1.0	Styrene	< 1.0
Ethyl methacrylate	< 1.0	1,1,2,2-Tetrachloroethane	< 1.0
4-Bromofluorobenzene	< 1.0	Toluene	< 1.0
Bromoform	< 1.0	1,1,1-Trichloroethane	< 1.0
Bromomethane	< 1.0	1,1,2-Trichloroethane	< 1.0
Carbon tetrachloride	< 1.0	Trichloroethene	< 1.0
Chlorobenzene	< 1.0	Trichlorofluoromethane	< 1.0
Dibromochloromethane	< 1.0	1,2,3-Trichloropropane	< 1.0
Chloroethane	< 1.0	Vinyl acetate	< 1.0
2-Chloroethyl vinyl ether	< 1.0	Vinyl chloride	< 1.0
Chloroform	< 1.0	Xylenes	< 1.0
Chloromethane	< 1.0	Tetrachloroethene	< 1.0
Dibromomethane	< 1.0		
Dichlorodifluoromethane	< 1.0		

NOTE: Analysis done by EPA method 8240.

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TO: Becky Woolsey
ADDRESS: Abenaki Geoenvironmental
P.O. Box 1018
Lewistown, MT 59457

LAB NO.: 93-34809
DATE: 08/31/93 da

WATER ANALYSIS

Mr. M Disposal, Proj. #1044

Well #34

Sampled 08/10/93 @ 0940

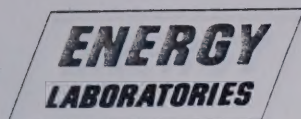
Submitted 08/11/93

Analyzed 08/24/93

<u>Constituent</u>	<u>µg/l</u>	<u>Constituent</u>	<u>µg/l</u>
Benzene	<1.0	1,1-Dichloroethane	<1.0
Bromochloromethane	<1.0	1,2-Dichloroethane	<1.0
Bromodichloromethane	<1.0	Iodomethane	<1.0
cis-1,3-Dichloropropene	<1.0	Methylene chloride	<1.0
trans-1,3-Dichloropropene	<1.0	1,1-Dichloroethene	<1.0
1,4-Difluorobenzene	<1.0	trans-1,2-Dichloroethene	<1.0
Ethylbenzene	<1.0	Styrene	<1.0
Ethyl methacrylate	<1.0	1,1,2,2-Tetrachloroethane	<1.0
4-Bromofluorobenzene	<10	Toluene	<1.0
Bromoform	<1.0	1,1,1-Trichloroethane	<1.0
Bromomethane	<1.0	1,1,2-Trichloroethane	<1.0
Carbon tetrachloride	<1.0	Trichloroethene	<1.0
Chlorobenzene	<1.0	Trichlorofluoromethane	<1.0
Dibromochloromethane	<1.0	1,2,3-Trichloropropane	<1.0
Chloroethane	<1.0	Vinyl acetate	<1.0
2-Chloroethyl vinyl ether	<1.0	Vinyl chloride	<1.0
Chloroform	<1.0	Xylenes	<1.0
Chloromethane	<1.0	Tetrachloroethene	<1.0*
Dibromomethane	<1.0		
Dichlorodifluoromethane	<1.0		

*Present but less than the practical quantitation limits.

NOTE: Analysis done by EPA method 8240.



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LABORATORY REPORT

TO: Becky Woolsey
ADDRESS: Abenaki Geoenvironmental
P.O. Box 1018
Lewistown, MT 59457

LAB NO.: 93-34807 -09
DATE: 08/31/93 da

WATER VOLATILE SURROGATE RECOVERY

10 µg/l Surrogate Standard Spike

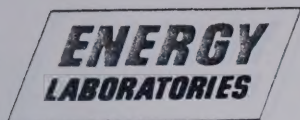
<u>SAMPLE NO.</u>	-----% recovery-----		
	<u>S1</u> <u>(TOL)#</u>	<u>S2</u> <u>(BFB)#</u>	<u>S3</u> <u>(DCE)#</u>
93-34807	100	103	99
93-34808	119	116	93
93-34809	114	105	105

S1 (TOL) = Toluene-d8
S2 (BFB) = Bromofluorobenzene
S3 (DCE) = 1,2-Dichloroethane-d4

QC LIMITS, % Recovery

80-120
80-120
80-120

#Column to be used to flag recovery values with an asterisk.



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LABORATORY REPORT FAX (406) 252-6069 • 1-800-735-4489

TO: Gregg Menge
ADDRESS: Abenaki Geoenvironmental
P.O. Box 1018
Lewistown, MT 59457

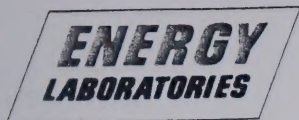
LAB NO.: 93-26018
DATE: 07/09/93 da

SOIL ANALYSIS

Proj. #1044, Mr. M. Disposal
Pond Sediment
Sampled 06/17/93 @ 1650
Submitted 06/22/93
Analyzed 06/29/93

Constituent	$\mu\text{g/g (ppm)}$	Constituent	$\mu\text{g/g (ppm)}$
PURGEABLE ORGANICS			
EPA METHOD 8260 - LONG LIST			
Acetone	<10	2,2-Dichloropropane	<0.20
Acrolein	<4.0	1,1-Dichloropropene	<0.20
Acrylonitrile	<4.0	cis-1,3-Dichloropropene	<0.20
Benzene	<0.20	trans-1,3-Dichloropropene	<0.20
Bromobenzene	<0.20	Ethylbenzene	<0.20
Bromochloromethane	<0.20	Hexachlorobutadiene	<0.20
Bromodichloromethane	<0.20	2-Hexanone	<4.0
Bromoform	<0.20	Iodomethane	<0.20
Bromomethane	<0.20	Isopropylbenzene	<0.20
2-Butanone (Methyl Ethyl Ketone)	<4.0	p-Isopropyltoluene	<0.20
n-Butylbenzene	<0.20	4-Methyl-2-pentanone (MIBK)	<4.0
sec-Butylbenzene	<0.20	Methylene chloride (Dichloromethane)	<0.20
tert-Butylbenzene	<0.20	Naphthalene	<0.20
Carbon disulfide	<0.20	n-Propylbenzene	<0.20
Carbon tetrachloride	<0.20	Styrene	<0.20
Chlorobenzene	<0.20	Tetrachloroethene (Tetrachloroethylene)	<0.20
Chlorodibromomethane	<0.20	1,1,1,2-Tetrachloroethane	<0.20
Chloroethane	<0.20	1,1,2,2-Tetrachloroethane	<0.20
2-Chloroethyl vinyl ether	<0.20	1,2,3-Trichlorobenzene	<0.20
Chloroform	<0.20	1,2,4-Trichlorobenzene	<0.20
Chloromethane	<0.20	1,1,1-Trichloroethane	<0.20
2-Chlorotoluene	<0.20	1,1,2-Trichloroethane	<0.20
4-Chlorotoluene	<0.20	Trichloroethene (Trichloroethylene)	<0.20
1,2-Dibromo-3-chloropropane (DBCP)	<0.20	Trichlorofluoromethane	<0.20
1,2-Dibromoethane (EDB)	<0.20	1,2,3-Trichloropropane	<0.20
Dibromomethane	<0.20	1,2,4-Trimethylbenzene	<0.20
1,2-Dichlorobenzene	<0.20	1,3,5-Trimethylbenzene	<0.20
1,3-Dichlorobenzene	<0.20	Toluene	<0.20
1,4-Dichlorobenzene	<0.20	Vinyl acetate	<0.20
Dichlorodifluoromethane	<0.20	Vinyl chloride (chloroethene)	<0.20
1,1-Dichloroethane	<0.20	Xylenes:	<0.20
1,2-Dichloroethane	<0.20		M
1,1-Dichloroethene	<0.20		P
cis-1,2-Dichloroethene	<0.20		O
trans-1,2-Dichloroethene	<0.20		
1,2-Dichloropropane	<0.20		
1,3-Dichloropropane	<0.20		

Method 8260 is the capillary equivalent to Method 8240.



ENERGY LABORATORIES, INC.

P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: Gregg Menge
ADDRESS: Abenaki Geoenvironmental
P.O. Box 1018
Lewistown, MT 59457

LAB NO.: 93-26018
DATE: 07/09/93 da

SOIL VOLATILE SURROGATE RECOVERY

2.0 µg/g Surrogate Standard Spike

<u>SAMPLE NO.</u>	-----% recovery-----		
	S1 (TOL)#	S2 (BFB)#	S3 (DCE)#
93-26018	101	97	99

<u>Total Nitrogen</u>	<u>Ammonia Nitrogen</u>	<u>Nitrate Nitrogen</u>
Ammonia	5	10
Benzene	5	10
Cadmium	1	2
Chromium	3	7
Copper	5	10
Mercury	1	2

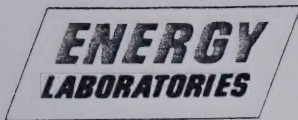
S1 (TOL) = Toluene-d8
S2 (BFB) = Bromofluorobenzene
S3 (DCE) = 1,2-Dichloroethane-d4

QC LIMITS, % Recovery

75-120
75-120
70-120

#Column to be used to flag recovery values with an asterisk.

Analysis done by EPA Method 8210



ENERGY LABORATORIES, INC.

P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: Gregg Menge
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P.O. Box 1018
Lewistown, MT 59457

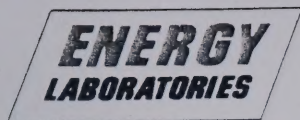
LAB NO.: 93-26018
DATE: 07/09/93 da

SOIL ANALYSIS

Proj. #1044, Mr. M. Disposal
Pond Sediment
Sampled 06/17/93 @ 1650
Submitted 06/22/93
Digested 06/22/93
Analyzed 06/25/93

Total Metals	Detection Limit, $\mu\text{g/g}$ (ppm)	$\mu\text{g/g}$ (ppm)
Arsenic	5	< 5
Barium	5	76
Cadmium	1	2
Chromium	3	9
Lead	5	9
Mercury	1	< 1
Selenium	5	250
Silver	5	< 5

Analysis done by EPA Method 3050.

**ENERGY LABORATORIES, INC.**P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489**LABORATORY REPORT**

TO: Gregg Menge
ADDRESS: Abenaki Geoenvironmental
P.O. Box 1018
Lewistown, MT 59457

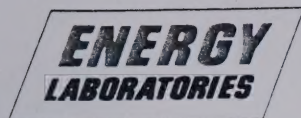
LAB NO.: 93-26019
DATE: 07/09/93 da

WATER ANALYSIS

Proj. #1044, Mr. M. Disposal
Runoff Into Pond
Sampled 06/17/93 @ 1200
Submitted 06/22/93
Analyzed 06/25/93

<u>Constituent</u>	<u>µg/l</u>	<u>Constituent</u>	<u>µg/l</u>
Benzene	< 1.0	1,1-Dichloroethane	< 1.0
Bromochloromethane	< 1.0	1,2-Dichloroethane	< 1.0
Bromodichloromethane	< 1.0	Iodomethane	< 1.0
cis-1,3-Dichloropropene	< 1.0	Methylene chloride	< 1.0
trans-1,3-Dichloropropene	< 1.0	1,1-Dichloroethene	< 1.0
1,4-Difluorobenzene	< 1.0	trans-1,2-Dichloroethene	< 1.0
Ethylbenzene	< 1.0	Styrene	< 1.0
Ethyl methacrylate	< 1.0	1,1,2,2-Tetrachloroethane	< 1.0
4-Bromofluorobenzene	< 10	Toluene	< 1.0
Bromoform	< 1.0	1,1,1-Trichloroethane	< 1.0
Bromomethane	< 1.0	1,1,2-Trichloroethane	< 1.0
Carbon tetrachloride	< 1.0	Trichloroethene	< 1.0
Chlorobenzene	< 1.0	Trichlorofluoromethane	< 1.0
Dibromochloromethane	< 1.0	1,2,3-Trichloropropane	< 1.0
Chloroethane	< 1.0	Vinyl acetate	< 1.0
2-Chloroethyl vinyl ether	< 1.0	Vinyl chloride	< 1.0
Chloroform	< 1.0	Xylenes	< 1.0
Chloromethane	< 1.0	Tetrachloroethene	< 1.0
Dibromomethane	< 1.0		
Dichlorodifluoromethane	< 1.0		

NOTE: Analysis done by EPA method 8240.



ENERGY LABORATORIES, INC.

P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489

LABORATORY REPORT

TO: Gregg Menge
ADDRESS: Abenaki Geoenvironmental
P.O. Box 1018
Lewistown, MT 59457

LAB NO.: 93-26019
DATE: 07/09/93 da

WATER VOLATILE SURROGATE RECOVERY

10 µg/l Surrogate Standard Spike

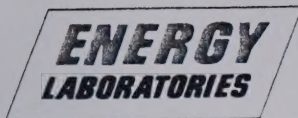
SAMPLE NO.	-----% recovery-----		
	S1 (TOL)#	S2 (BFB)#	S3 (DCE)#
93-26019	95	110	102

S1 (TOL) = Toluene-d8
S2 (BFB) = Bromofluorobenzene
S3 (DCE) = 1,2-Dichloroethane-d4

QC LIMITS, % Recovery

80-120
80-120
80-120

#Column to be used to flag recovery values with an asterisk.

**ENERGY LABORATORIES, INC.**P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-735-4489**LABORATORY REPORT**

TO: Gregg Menge
ADDRESS: Abenaki Geoenvironmental
P.O. Box 1018
Lewistown, MT 59457

LAB NO.: 93-26019
DATE: 07/08/93 da

WATER ANALYSIS

Proj. #1044, Mr. M. Disposal
Runoff Into Pond
Sampled 06/17/93 @ 1200
Submitted 06/22/93

<u>Constituent</u>	<u>mg/l (ppm)</u>	<u>Date Analyzed</u>
Potassium	12	06/24/93
Sodium	41	06/24/93
Calcium	77	06/24/93
Magnesium	54	06/24/93
Sulfate	158	06/30/93
Chloride	68	06/30/93
Carbonate	0	06/23/93
Bicarbonate	245	06/23/93
Total Dissolved Solids @ 180°C	647	06/24/93
Total Alkalinity as CaCO ₃	201	06/23/93
Specific Conductance @ 25°C	667 μ mhos/cm	06/23/93
pH	6.4 s.u.	06/23/93
Nitrate as N	18.7	06/25/93
Ammonia as N	0.4	06/25/93
Chemical Oxygen Demand	25	06/24/93
Total Suspended Solids	515	06/23/93

Dissolved Metals

Arsenic	<0.005	06/29/93
Barium	<0.1	06/29/93
Cadmium	<0.001	06/29/93
Chromium	<0.01	06/29/93
Iron	<0.03	06/29/93
Lead	<0.01	06/29/93
Manganese	<0.01	06/29/93
Mercury	<0.001	06/23/93
Selenium	<0.005	06/24/93
Silver	<0.005	06/29/93

APPENDIX C
WATER WELL LOGS

I w

File No.

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

[illegible]

abstract principles of mathematics

DEPARTMENT 507

DRILLER: Please give this copy to the well owner to complete reverse side
OWNER: Complete reverse side form and return to **BOULE**

WELL LOG REPORT

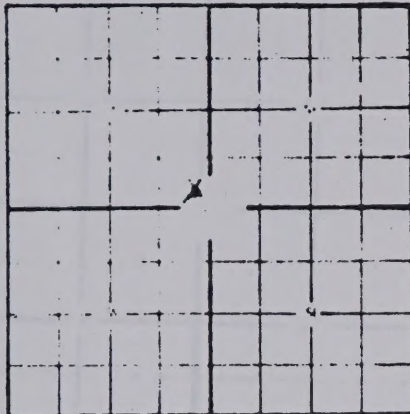
1. WELL OWNER

Name Clark Johnson

2. CURRENT MAILING ADDRESS

Gilt Edge Route
Lewistown, Montana 59457

3. WELL LOCATION



SE $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$ Section X8
 Township 15 N/S Range 19 E/W
 County _____
 Lot _____ Block _____
 Subdivision _____
 Well Elevation _____
 Accuracy: $\pm 10'$ $\pm 50'$ $\pm 100'$

4. DRILLING METHOD

_____ cable _____ bored
☒ forward rotary _____ reverse rotary _____ jetted
 other (specify) _____

5. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations	and/or
6" in	4" steel wall	0	12	Kind Size	From (feet) To (feet)
	4" pvc 160#	12	280	1/8" slots	260 280

Was casing left open end? ☒ Yes _____ No
 Was a packer or seal used? ☒ Yes _____ No
 If so, what material _____ rubber
 Was the well gravel packed? _____ Yes ☒ No
 Was the well grouted? ☒ Yes _____ No
 To what depth? 15'
 Material used in grouting clay
 Well head completion: Pileup adapter _____
 12 in. above grade _____ other _____
 (If other, specify) _____
 Pump horsepower _____, pump type _____
 Pump intake level _____ feet below land surface
 Power (electric, diesel, etc.) _____

6. WATER LEVEL

Static water level 110' feet below land surface
 Flowing, closed-in pressure _____ psi
 _____ gpm flow through _____ inch pipe
 Controlled by: _____ valve _____ reducers _____ other
 (If other, specify) _____

7. WELL TEST DATA

_____ pump _____ bailer _____ other
 (if other, specify) air lift
 Pumping level below land surface:
200 ft. after 1 hrs. pumping 50 gpm
 ft. after _____ hrs. pumping _____ gpm

8. WAS WELL PLUGGED OR ABANDONED?

Yes ☒ No
 If yes, how? _____

9. DATE STARTED

3/9/81
 DATE COMPLETED 3/13/81

10. WELL LOG

Depth (ft.)

From	To	Formation
0	16	yellow shale & sandstone
16	28	sticky gray shale
28	40	shale
40	220	red and gray shale streaks of rock
220	255	brown & white sandstone
255	263	red shale
263	265	cap rock
265	280	gray coarse-grained sandstone water

11. DRILLER'S CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

3/15/81

DeBuff Drilling Co.

Gilt Edge Rte. Lewistown, Mt.

Address William J. DeBuff 346
 License No. _____

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION

32 SOUTH EMMET

HELENA, MONTANA 59601

449-3636

DNRC

DEPARTMENT COPY

Well owner must complete Form 602 on reverse side.

WL-4725

1. WELL OWNER Name <u>Jim Larson</u>	2. CURRENT MAILING ADDRESS <u>Gilt Edge Route</u> <u>Lewistown Mt</u>																																							
3. PROPOSED USE ☒ domestic (includes lawn and garden); ☐ stock; ☐ municipal; ☐ industrial; ☐ irrigation ☐ other (specify) _____																																								
4. WELL LOCATION <!-- Grid representation of the well location --> <u>1/4 SW 1/4 NW 1/4 SW 1/4 Section 8</u> <u>T. 15 R. 19</u> ☒ Nor S ☒ E or W OR, Lot _____ Block _____ Subdivision _____ City _____ County _____ Elevation _____ Accuracy: ☐ ±10'; ☐ ±50'; ☐ ±100';	8. WELL TEST DATA ☐ pump ☒ bailer ☐ other (if other, specify) _____ Pumping level below land surface: <u>100</u> ft. after <u>1</u> hrs. pumping <u>15</u> gpm <u> </u> ft. after <u> </u> hrs. pumping <u> </u> gpm																																							
9. WAS WELL PLUGGED OR ABANDONED? ☐ Yes ☒ No If yes, how? _____																																								
10. DATE STARTED <u>9/28/78</u> DATE COMPLETED <u>5/24/79</u>																																								
11. WELL LOG <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2">Depth (ft.)</th> <th>Formation</th> </tr> <tr> <th>From</th> <th>To</th> <th></th> </tr> </thead> <tbody> <tr> <td>0</td> <td>5</td> <td>yellow + gray shale</td> </tr> <tr> <td>50</td> <td>65</td> <td>sandstone streaks of sandstone</td> </tr> <tr> <td>65</td> <td>92</td> <td>gray-blue shale</td> </tr> <tr> <td>92</td> <td>95</td> <td>soft + gray shale</td> </tr> <tr> <td>95</td> <td>110</td> <td>hard, light blue sandstone</td> </tr> <tr> <td>110</td> <td>112</td> <td>greenish-gray shale</td> </tr> <tr> <td>112</td> <td>120</td> <td>gray shale + sandstone</td> </tr> <tr> <td>120</td> <td>260</td> <td>gray-red shale</td> </tr> <tr> <td>260</td> <td>320</td> <td>red shale</td> </tr> <tr> <td>320</td> <td>350</td> <td>blue-shale streaks of rock</td> </tr> <tr> <td>350</td> <td> </td> <td>white sandstone + water</td> </tr> </tbody> </table>		Depth (ft.)		Formation	From	To		0	5	yellow + gray shale	50	65	sandstone streaks of sandstone	65	92	gray-blue shale	92	95	soft + gray shale	95	110	hard, light blue sandstone	110	112	greenish-gray shale	112	120	gray shale + sandstone	120	260	gray-red shale	260	320	red shale	320	350	blue-shale streaks of rock	350		white sandstone + water
Depth (ft.)		Formation																																						
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5. DRILLING METHOD ☒ cable, ☐ bored, ☒ forward rotary, ☐ reverse rotary, ☐ jetted, ☐ other (specify) _____																																								
6. WELL CONSTRUCTION AND COMPLETION <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th rowspan="2">Size of drilled hole</th> <th rowspan="2">Size and weight of casing</th> <th rowspan="2">From (feet)</th> <th rowspan="2">To (feet)</th> <th colspan="2">Perforations</th> <th rowspan="2">Screen</th> <th rowspan="2">X and/or</th> </tr> <tr> <th>Kind</th> <th>Size</th> </tr> </thead> <tbody> <tr> <td>6 1/4"</td> <td>4" PVC</td> <td>12</td> <td>350</td> <td>3/8"</td> <td>250</td> <td>350</td> <td></td> </tr> <tr> <td></td> <td>4 1/4" steel</td> <td>0</td> <td>12</td> <td>holes</td> <td></td> <td></td> <td></td> </tr> </tbody> </table>		Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations		Screen	X and/or	Kind	Size	6 1/4"	4" PVC	12	350	3/8"	250	350			4 1/4" steel	0	12	holes																
Size of drilled hole	Size and weight of casing					From (feet)	To (feet)			Perforations		Screen	X and/or																											
		Kind	Size																																					
6 1/4"	4" PVC	12	350	3/8"	250	350																																		
	4 1/4" steel	0	12	holes																																				
Was casing left open end? ☐ Yes, ☒ No Was a packer or seal used? ☒ Yes, ☐ No If so, what material <u>rubber</u> Was the well gravel packed? ☐ Yes, ☒ No Was the well grouted? ☒ Yes, ☐ No To what depth? <u>20 feet</u> Material used in grouting <u>cement</u> Well head completion: Pileless adapter ☒ 12 in. above grade ☐ other ☐ (if other, specify) _____ Pump horsepower _____, pump type _____ Pump intake level _____ feet below land surface Power (electric, diesel, etc.) _____																																								
7. WATER LEVEL Static water level <u>70'</u> feet below land surface If flowing, closed-in pressure _____ psi _____ gpm flow through _____ inch pipe Controlled by: ☐ valve, ☐ automatic, ☐ other (if other, specify) _____																																								
12. DRILLER'S CERTIFICATION This well was drilled under my jurisdiction and this report is true to the best of my knowledge. <u>10/10/78</u> Date <u>DeBuff Drilling</u> Firm Name <u>Gilt Edge Route</u> Address <u>Wm. DeBuff</u> Name																																								

North of Clark Johnson

M W

Form No. 10-79

File No. _____

D

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well

1. WELL OWNER Name <u>Ralph Bindal</u>	6. WATER LEVEL Static water level <u>4-8'</u> feet below land surface If flowing, closed-in pressure _____ psi gpm flow through _____ inch pipe Controlled by: _____ valves, _____ reducers, _____ other (if other, specify) _____																					
2. CURRENT MAILING ADDRESS <u>Witt Ridge Rd</u> <u>Sanita Township, Mont. 59457</u>	7. WELL TEST DATA _____ pump ☒ boiler _____ other (if other, specify) _____ Pumping level below land surface: <u>216</u> ft. other <u>4</u> hrs. pumping <u>15</u> gpm ft. other _____ hrs. pumping _____ gpm																					
3. WELL LOCATION <u>NE 1/4 NW 1/4</u> Section <u>8</u> Township <u>15</u> Range <u>19</u> County <u>PERKINS</u> Lot _____ Block _____ Subdivision _____ Well Elevation <u>5100'</u> Accuracy: <u>±10'</u> <u>±50'</u> <u>X ±100'</u>	8. WAS WELL PLUGGED OR ABANDONED? Yes ☒ No _____ (If yes, how?) _____ 9. DATE STARTED <u>12-22-82</u> DATE COMPLETED <u>2-6-83</u> 10. WELL LOG <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2">Depth (ft.)</th> <th>Formation</th> </tr> <tr> <th>From</th> <th>To</th> <th></th> </tr> </thead> <tbody> <tr> <td>0</td> <td>32</td> <td>Gray shale</td> </tr> <tr> <td>32</td> <td>65</td> <td>Red clay</td> </tr> <tr> <td>65</td> <td>156</td> <td>gray sandy shale</td> </tr> <tr> <td>156</td> <td>190</td> <td>sandy shale & rock str</td> </tr> <tr> <td>190</td> <td>220</td> <td>sand (aquifer)</td> </tr> </tbody> </table>	Depth (ft.)		Formation	From	To		0	32	Gray shale	32	65	Red clay	65	156	gray sandy shale	156	190	sandy shale & rock str	190	220	sand (aquifer)
Depth (ft.)		Formation																				
From	To																					
0	32	Gray shale																				
32	65	Red clay																				
65	156	gray sandy shale																				
156	190	sandy shale & rock str																				
190	220	sand (aquifer)																				
4. DRILLING METHOD ☒ Rotary drill _____ ☐ Auger _____ ☐ Other (specify) _____	11. DRILLER'S CERTIFICATION This well was drilled under my jurisdiction and this report is true to the best of my knowledge. <u>2-16-83</u> _____ Kelly Drilling Co. Box <u>244</u> Roundup, Mont. Address <u>Charles Kelly</u> 169 Signature _____ License No. _____																					
5. WELL CONSTRUCTION AND EQUIPMENT <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Size of drilled hole</th> <th>Size and weight of casing</th> <th>Open hole</th> <th>Bottom</th> <th>Gravel</th> <th>Gravel</th> <th>Gravel</th> </tr> </thead> <tbody> <tr> <td><u>6 1/4"</u></td> <td><u>4 1/2"</u> <u>160 psi</u></td> <td><u>0</u></td> <td><u>220</u></td> <td><u>3/8"</u></td> <td><u>180</u></td> <td><u>220</u></td> </tr> </tbody> </table> Was casing left open end? ☒ Yes _____ No _____ Was a packer or seal used? ☒ Yes _____ No _____ If so, what material? <u>Rubber</u> Was the well gravel packed? ☒ Yes _____ No _____ Was the well grouted? ☒ Yes _____ No _____ To what depth? <u>12 ft</u> Material used in grouting <u>Gravel</u> Well head completion: _____ 12 in. screen _____ (If other, specify) <u>None</u> Pump horsepower <u>3/4</u> pump type <u>Sub</u> Pump intake level <u>216</u> feet below land surface Power (electric, diesel, etc.) <u>Electric</u>		Size of drilled hole	Size and weight of casing	Open hole	Bottom	Gravel	Gravel	Gravel	<u>6 1/4"</u>	<u>4 1/2"</u> <u>160 psi</u>	<u>0</u>	<u>220</u>	<u>3/8"</u>	<u>180</u>	<u>220</u>							
Size of drilled hole	Size and weight of casing	Open hole	Bottom	Gravel	Gravel	Gravel																
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WELL LOG REPORT

Ken Thatcher

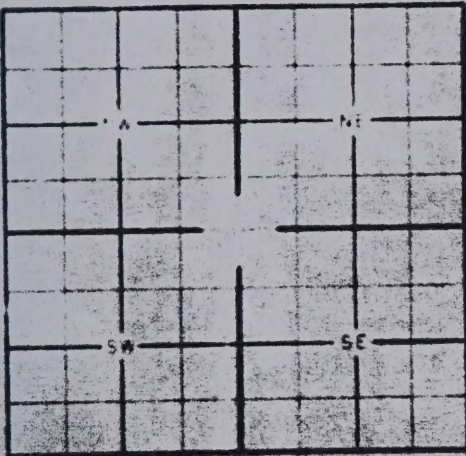
Notice: This form is to be filled out by the well owner within 60 days after completion of the well and Form 602, Notice of Completion, must be filed by the well owner within 60 days after the water has been put to beneficial use.

1. WELL OWNER
Name Art Larson

2. CURRENT MAILING ADDRESS
Box 112
Sumtown, Montana

3. PROPOSED USE ☒ domestic (includes lawn and garden); ☐ stock; ☐ municipal; ☐ industrial;
☐ irrigation ☐ other (specify) _____

4. WELL LOCATION



SW x NW x SE x Section R
T. 15 N R. 19 E
N or S E or W
OR, Lot _____ Block _____
Subdivision _____
City _____ County Fergus
Elevation _____ Accuracy: ±10', ±50', ±100'

8. WELL TEST DATA pump ☒ bailer ☐ other _____
(If other, specify) _____
Pumping level below land surface:
100 ft. after 1 hrs. pumping 15 gpm
ft. after _____ hrs. pumping _____ gpm

9. WAS WELL PLUGGED OR ABANDONED? ☐ Yes ☒ No
If yes, how? _____

10. DATE STARTED 4/24/78
DATE COMPLETED 5/12/78

11. WELL LOG

Depth (ft.)		Formation
From	To	
0	10	Topsoil + clayey shale
10	90	blue + yellow ss shale
		stratified of sandstone
90	250	Red shale. Strata of
		blue + gray
250	300	blue gray shale given
		of 1 light gray sandstone
300	320	light gray hard sandstone
		+ water

5. DRILLING METHOD ☒ cable, ☐ bored,
☒ forward rotary, ☐ reverse rotary, ☐ jetted,
☐ other (specify) _____

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations ☒ and/or Screen		
				Kind	From (feet)	To (feet)
6 1/4"	4 1/2" 20 PVC 160 psi	0	320	3/8 holes	220	320

Was casing left open end? ☐ Yes ☒ No
Was a packer or seal used? ☒ Yes ☐ No
If so, what material rubber
Was the well gravel packed? ☐ Yes ☐ No
Was the well grouted? ☒ Yes ☐ No
To what depth? 220
Material used in grouting Rubber seal + cement
Well head completion: ☒ Flush adapter ☐ _____
12 in. above grade _____
(If other, specify) _____
Pump manufacturer _____ pump type _____
Pump intake level _____ feet below land surface
Pump electrical, brand, size _____

7. WATER LEVEL
Static water level 25' feet below land surface
If flowing, discharge in gallons _____
_____ and flow direction _____
Estimated flow _____
Notes _____

12. DRILLER'S CERTIFICATION
This well was drilled under my supervision and this report is true to the best of my knowledge.
4/24/78
D. Ruff Drilling
Route 2 Box 185

EW

G

Form No 603 R9/82

RECEIVED
File No. DAY 03 1984

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well.
MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION

1. WELL OWNER Name <u>Track Sweeney</u>				6. WATER LEVEL Static water level <u>60</u> feet below land surface If flowing, closed-in pressure _____ psi _____ gpm Controlled by: _____ valve, _____ reducers, _____ other (specify) _____			
2. CURRENT MAILING ADDRESS <u>P.O. Box 636</u> <u>Leavittown MT 59627</u>				9. WELL TEST DATA ☒ pump ☐ bailer other (specify) _____ Pumping level below land surface: <u>140</u> ft. at <u>3</u> hrs. pumping <u>12</u> gpm If other _____ hrs. pumping _____ gpm			
3. WELL LOCATION County <u>Richmond</u> Township <u>15</u> N/R <u>18</u> Range <u>18</u> E/W <u>S1/4 N 1/4</u> Section <u>3</u> Lot _____ Block _____ Subdivision _____				10. WAS WELL PLUGGED OR ABANDONED? Yes ☐ No ☒ If yes, how? _____			
4. PROPOSED USE Domestic ☐ Stock ☐ Irrigation ☐ Other (specify) _____				11. DATE COMPLETED <u>April 3, 1984</u>			
5. DRILLING METHOD _____ core _____ ☒ forward rotary, ☐ reverse rotary, ☐ other (specify) _____				12. WELL LOG Depth (ft.) From To Formation			
8. WELL CONSTRUCTION AND COMPLETION				From To Formation <u>0</u> <u>30</u> <u>Slatey shale w/yellow sandstone streaks</u> <u>30</u> <u>70</u> <u>Blue shale</u> <u>70</u> <u>90</u> <u>White sandstone w/shale layers</u> <u>90</u> <u>95</u> <u>Blue shale</u> (same as 70-90) <u>95</u> <u>115</u> <u>Green sandstone</u> <u>115</u> <u>125</u> <u>Red beds</u> <u>125</u> <u>221</u> <u>Hard Rock</u> <u>221</u> <u>225</u> <u>Red shale</u> <u>225</u> <u>237</u> <u>Hard Rock</u> <u>237</u> <u>247</u> <u>shale + part w/layers sandst.</u> <u>247</u> <u>261</u> <u>Hard Rock</u> <u>261</u> <u>297</u> <u>White sandstone (water)</u>			
Size of drilled hole <u>5 5/8"</u>	Size and weight of casing <u>4 1/2" OD</u> <u>PVC</u> <u>200 ft. 140 lb.</u>	From (feet) <u>0'</u>	To (feet) <u>297'</u>	Porting Size <u>5 1/8" hole</u>	From (feet) <u>72</u> <u>250</u>	To (feet) <u>92</u> <u>290</u>	
Was casing left open end? ☒ Yes ☐ No Was a packer or seal used? ☒ Yes ☐ No If so, what material? <u>rubber</u> Was the well gravel packed? ☐ Yes ☒ No Was the well grouted? ☒ Yes ☐ No To what depth? <u>70 ft.</u> Material used in grouting: <u>concrete</u> Well head completion: Pile adapter ☒ Yes ☐ No Top of casing 12 in. or greater above grade ☒ Yes ☐ No							
7. WHAT IS THE TEMPERATURE OF THE WATER? <u>40</u> Degrees Fahrenheit ☐ Measured ☒ Estimated							
12. DRILLER'S CERTIFICATION This well was drilled under my jurisdiction and this report is true to the best of my knowledge. <u>April 3, 1984</u> <u>Singley Drilling</u> Firm Name <u>1016 W. Broadway, Leavittown MT</u> Address <u>Wally O. Singley</u> 398 Signature License No.							

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION

32 SOUTH EWING

HELENA, MONTANA 59620

445-3063

DNRC

DEPARTMENT COPY

DRILLER: Please give this copy to the well owner to complete reverse side.

OWNER: Complete reverse side Form 602 and send to DNRC.

5A

H

(11)

OF MONTANA

Department of Natural Resources and Conservation

Well LOG REPORT

BW

(H)

This form shall be filed by the water well driller on any well drilled after Jan. 1, 1973 within sixty (60) days of completion.

Name Marvin E. Henty Address Box 3 Four Towns 124

WELL LOCATION: County Fergus SE 14 SW 8, Twp 15 S R 19 W

PROPOSED USE: ☒ Domestic ☒ Stock ☐ Municipal ☐ Industrial ☐ Other (if other, specify) _____

METHOD DRILLED: ☒ Cable ☐ Bored
☒ Forward Rotary ☐ Reverse Rotary
☐ Jetted ☐ Other (if other, specify) _____

3. WELL LOG:

Depth (ft.)

From To

Formations

0 80

80 120

Layers of yellow rock
Red shale. Varied
sandstone.

WELL Casing: 5 7/8 inches: Depth 120 ft.
 Casing: ☒ Steel ☒ Plastic ☐ Concrete
☐ Threaded ☐ Welded ☐ Other (if other, specify) _____

Well Dia.: From 2 inches up to 120 feet
2 1/4 inches up to 120 feet
2 1/4 inches up to 120 feet

Was perforated pipe used? ☒ Yes ☐ No
 Length of pipe perforated 40 feet
 Was casing left open end? ☒ Yes ☐ No
 Was a well screen installed? ☐ Yes ☒ No
 Material Dia. inches
 (stainless steel, bronze, etc.)

Perforation type: ☐ slots ☒ holes
 Size 5/16 inch from 80 feet to 120 feet
 Size inch from feet to feet
 Size inch from feet to feet

Was a packer or seal used? ☒ Yes ☐ No
 If so, what material Rubber

Well type: ☐ Straight screen ☐ Graveled
 Was the well grouted? ☒ Yes ☐ No
 To what depth? 40 feet

Material used in grouting Cement
 Well head completion: Pitless adapter ☒
12" above grade ☐ Other
 (If other, specify) _____

Was the well disinfected? ☒ Yes ☐ No

WATER LEVEL:

Static water level 40 ft. below land surface
 If flowing: closed-in pressure psi
 GPM flow through inch pipe
 Controlled by: ☐ Valve ☐ Reducers
 Other, specify _____

WELL TEST DATA: ☒ Pump ☐ Bailer ☒ Other
 (If other, specify) air

Pumping rate below land surface:
84 gpm at 2 hrs. pumping 25 gpm
 gpm at hrs. pumping gpm

(Use separate sheet if necessary)

9. DATE STARTED: Feb 2, 197610. DATE COMPLETED: Apr 2, 1976

11. WAS WELL PLUGGED OR ABANDONED? ☐ Yes ☒ No
 If so, how _____

12. DRILLER'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

George O. Sengley 19
 Driller's or Firm Name License No.

Box 2 Box 4 Four Towns 124
 Address

Signed by

May 1976

(H)

(11)

2A

1. The first part of the report is a general description of the area.

2. The second part of the report is a detailed description of the area.

3. The third part of the report is a detailed description of the area.

4. The fourth part of the report is a detailed description of the area.

5. The fifth part of the report is a detailed description of the area.

6. The sixth part of the report is a detailed description of the area.

7. The seventh part of the report is a detailed description of the area.

8. The eighth part of the report is a detailed description of the area.

9. The ninth part of the report is a detailed description of the area.

10. The tenth part of the report is a detailed description of the area.

11. The eleventh part of the report is a detailed description of the area.

12. The twelfth part of the report is a detailed description of the area.

13. The thirteenth part of the report is a detailed description of the area.

14. The fourteenth part of the report is a detailed description of the area.

15. The fifteenth part of the report is a detailed description of the area.

STORM WATER ANALYSIS
APPENDIX D

APPENDIX D
STORM WATER ANALYSIS

LOCATION:

The storm water analysis was conducted at the site of the proposed development. The analysis was conducted on the storm water runoff from the proposed development. The analysis was conducted on the storm water runoff from the proposed development. The analysis was conducted on the storm water runoff from the proposed development.

DESCRIPTION:

The storm water analysis was conducted on the storm water runoff from the proposed development. The analysis was conducted on the storm water runoff from the proposed development. The analysis was conducted on the storm water runoff from the proposed development. The analysis was conducted on the storm water runoff from the proposed development.

RESULTS:

The storm water analysis was conducted on the storm water runoff from the proposed development. The analysis was conducted on the storm water runoff from the proposed development. The analysis was conducted on the storm water runoff from the proposed development. The analysis was conducted on the storm water runoff from the proposed development.

There is a 10' x 10' area of the site that is not covered by the proposed development. This area is located at the corner of the site. The area is not covered by the proposed development. The area is not covered by the proposed development. The area is not covered by the proposed development.

There is a 10' x 10' area of the site that is not covered by the proposed development. This area is located at the corner of the site. The area is not covered by the proposed development. The area is not covered by the proposed development. The area is not covered by the proposed development.

THE UNIVERSITY

OF CALIFORNIA

SURFACE DRAINAGE AND RUNOFF

M I S T E R M L A N D F I L L **Lewistown, Montana**

INTRODUCTION:

This report presents the findings of a drainage analysis of the Mister M Landfill in Lewistown, Montana. The analysis compares the relative magnitude of runoff from the site in the existing condition to runoff with the landfill capped and vegetated. The site was modeled using Soil Conservation Service TR-20 methodology and runoff determined for Antecedent Moisture Conditions I and II.

LOCATION:

The Mister M Landfill is located east of Lewistown and approximately a quarter of a mile north of State Route 200 where it crosses Boyd Creek. Reference is made to the Pike Creek, Montana, 7.5' Quadrangle for a map location.

WATERSHED:

The landfill site is in the Boyd Creek watershed. The landfill itself forms a topographic high that drains south to a small pond near the south end of the site. Overflow from this pond joins with runoff from the east side of the site to form an intermittent stream that joins Boyd Creek south of State Route 200.

TOPOGRAPHY:

The landfill forms a ridge that runs from the pond at the south end northeasterly for a distance of approximately 1,200 feet. The difference in elevation across the site from south to north is approximately 80 feet with an elevation of roughly 4,190 at the pond and 4,270 at the north end of the site.

There is a 30' to 40' near vertical drop for a distance of 600' to 700' along the northwest side of the site. At the base of this drop there is a flat area of approximately 3 acres that slopes slightly northeast toward the landfill. Runoff from this area and the west face of the landfill are carried 400 feet south through a deep ravine to the pond.

There is a drainage divide that runs 200' to 300' southeast of the crest of the landfill. The east face of the landfill and west side of this divide drain to the pond generally as indicated on the enclosed Figure 1. Southeast of this divide is an area of

EVERETT TRAIL AND RUNOFF
MISTER M. L. L. L.
Lewistown, Montana

INTRODUCTION:

This report presents the findings of a drainage analysis of the Mister M Landfill in Lewistown, Montana. The analysis compares the relative magnitude of runoff from the site to the existing condition of runoff with the landfill capped and vegetated. The analysis was modeled using Soil Conservation Service 22-33 methodology and runoff determined for antecedent moisture conditions I and II.

LOCATION:

The Mister M Landfill is located east of Lewistown and approximately a quarter of a mile north of State Route 300 where it crosses Boyd Creek. Reference is made to the Pike Creek, Montana, 7.5' Quadrangle for a map location.

WATERWAYS:

The landfill site is in the Boyd Creek watershed. The landfill itself forms a topographic high that drains south to a small pond near the north end of the site. Overflow from this pond joins with runoff from the east side of the site to form an intermittent stream that joins Boyd Creek south of State Route 300.

TOPOGRAPHY:

The landfill forms a ridge that runs from the pond at the north end northeasterly for a distance of approximately 1,500 feet. The difference in elevation across the site from north to south is approximately 80 feet with an elevation of roughly 4,100 at the pond and 4,200 at the north end of the site.

There is a 30' to 40' near vertical drop for a distance of 600' to 700' along the northwest side of the site. At the base of this drop there is a flat area of approximately 2 acres that slopes slightly northeast toward the landfill. Runoff from this area and the west face of the landfill are carried 400 feet north through a deep ravine to the pond.

There is a drainage divide that runs 300' to 500' southeast of the crest of the landfill. The east face of the landfill and west side of this divide drain to the pond generally as indicated on the enclosed Figure 1. Southeast of this divide is an area of

approximately 9 acres that drains southwesterly along the landfill access road. Runoff from this area does not reach the pond, but instead skirts east and south of it and eventually reaches Boyd Creek.

METHODOLOGY:

The site was modeled using the computer program "Hydrocad" by Applied Microcomputer Systems of Chocura, New Hampshire. The program uses the Soil Conservation Services (SCS) TR-20 as a base.

The first step in creating the model is to identify the drainage areas or "subcatchments." Subcatchments in the model are individual drainage areas above a point of analysis. Subcatchments are designated by hexagons and are delineated by dash/dot lines on the enclosed Figure 1. Figure 1 was created from survey data by Nash Surveying of Lewistown, Montana, an aerial photo of the site, and observations made by R.W. Gillespie & Associates.

Within subcatchments, the travel paths used to determine the time of concentration are identified on Figure 1 as "T_c path" and drainage directional arrows. The nature of the flow - i.e., sheet flow, shallow concentrated flow (SCF), or channel flow (CF) - is also noted on Figure 1.

All soils on the site were assumed to be Hydrologic Soil Group D. The following curve numbers were used to characterize the relative amount of runoff from the site for different ground surface conditions and Antecedent Moisture Conditions (AMC) I and II:

GROUND COVER	HYDROLOGIC CONDITION	CURVE NUMBER	
		AMC I	AMC II
Brush-brush-weed-grass mixture with brush the major element	Poor	67	83
Bare soil	--	86	94

The summary data sheets for subcatchments found on pages 2 and 3 and pages 12 and 13 of the attached Hydrocad Report detail the areas, curve numbers, and ground cover within the subcatchments. This data does not change for computer runs of the storms analyzed; therefore, the summaries only appear for the 25-year storm. This data is provided in tabular form on pages 7 through 11 and 16 through 20 of the Hydrocad Report for the 10-year and 2-year storms, Antecedent Moisture Condition I, and the 25-, 10-, and 2-year storms, Antecedent Moisture Condition II.

approximately 5 acres that drains southeasterly along the landfill access road. Runoff from this area does not reach the pond, but instead flows east and north of it and eventually reaches Boyd Creek.

HYDROLOGIC

The site was modeled using the computer program "Hydrocad" by Applied Microcomputer Systems of Channahon, New Hampshire. The program uses the Soil Conservation Service (SCS) TR-20 as a basis.

The first step in creating the model is to identify the drainage area or "subcatchment". Subcatchments in the model are individual drainage areas above a point of analysis. Subcatchments are designated by hexagons and are delineated by dashed lines on the enclosed Figure 1. Figure 1 was created from survey data by Nash Engineering of Lewistown, Montana, an aerial photo of the site, and observations made by A.W. Gillespie & Associates.

Within subcatchments, the travel paths used to determine the time of concentration are identified as "to path" and "from path". The nature of the flow - i.e., sheet flow, shallow concentrated flow (SCF), or channel flow (CF) - is also noted on Figure 1.

All soils on the site were assumed to be Hydrologic Soil Group D. The following curve numbers were used to characterize the relative amount of runoff from the site for different ground surface conditions and antecedent moisture conditions (AMC) I and II:

GROUND COVER	HYDROLOGIC CONDITION	CURVE NUMBER AMC I AMC II
Forest		55
Grass mixture with brush the major element		55
Bare soil		94

The summary data sheets for subcatchments found on pages 1 and 2 and pages 11 and 12 of the attached Hydrocad Report detail the areas, curve numbers, and ground cover within the subcatchments. This data does not change for computer runs of the storm analysis. Therefore, the summaries only appear for the 25-year storm. This data is provided in tabular form on pages 1 through 11 and 12 through 18 of the Hydrocad Report for the 10-year and 2-year storms, Antecedent Moisture Condition I, and the 25-, 10-, and 2-year storms, Antecedent Moisture Condition II.

Runoff from subcatchments was "travel timed" downstream or transported via "reaches" from one point to another. Reaches may be swales, ditches, pipes, or streams. In the model and on Figure 1, reaches are designated by squares or rectangles. There were only 2 reaches identified in this model: Reach 21 carries runoff from Subcatchment 1 to the pond and Reach 22 is a ditch with an assumed geometry, slope, and length that carries water off site. Reach 22 has no real significance in this model.

The pond in the model is identified on Figure 1 and as a triangle in the schematic to be found on page 1 of the Hydrocad Report. The stage/storage table shown on pages 5 and 15 of the Hydrocad Report for Pond 31 was calculated from the surface area of the pond as shown on the aerial photo (scale 1" = 100') and the following assumptions:

1. The pond is 5 feet deep.
2. There is no outlet other than the dike at the south end of the pond which was modeled as a broad crested weir. Water level in the pond is lowered when water evaporates between rainfalls.
3. There is 3 feet of freeboard in the pond whenever a storm with a frequency of 2, 10, or 25 years occurs.
4. The pond has side slopes of 1:1 and a flat bottom.

The model was run for these Type II, 24-hour rainfalls with frequencies of 25, 10, and 2 years. These values were taken from NOAA Atlas 2, Volume I, and are as follows:

24-HOUR STORM	RAINFALL (Inches)
-----	-----
25 YR	3.0
10 YR	2.6
2 YR	1.6

In this model, runoff was analyzed at two points: Pond 31 and Reach 22. Runoff for the site in the existing condition and the capped condition for both Antecedent Moisture Conditions I and II were determined. The subcatchments in both the existing condition and capped condition were assumed to cover the same area. At this time, there are no plans that propose changing existing drainage patterns. Within the subcatchments, there were some minor changes made that affected the time of concentration path:

Subcatchment 2 - With the existing landfill capped and the area west of the present landfill becoming the active landfill, it was assumed that an access road would cross the south end of this subcatchment and would require a culvert to carry stormwater beneath the road. This

Resault from subcatchment was "travel time" determined by transporting via "reservoir" from one point to another. Reservoirs are in series, ditch, or stream. In this model and in Figure 1, reservoirs are designated by separate or rectangular. There were only 2 reservoirs identified in this model: Reservoir 1 carried Resault from subcatchment 1 to the pond and Reservoir 2 is a ditch with an assumed geometry, slope, and length that carries water off site. Resault 2 has no real significance in this model.

The pond in the model is identified as Figure 1 and as a principle in the schematic as the pond on page 1 of the Hydrologic Report. The schematic shows the pond shown on pages 2 and 3 of the Hydrologic Report. The pond 2 was calculated from the surface area of the pond as shown on the aerial photo (scale 1" = 100') and the following assumptions:

1. The pond is 2 feet deep.
 2. There is an outlet under the dam at the north end of the pond which was modeled as a broad crested weir. Water level in the pond is lowered when water evaporates between rainfalls.
 3. There is a foot of freeboard in the pond whenever a storm with a frequency of 2, 10, or 25 years occurs.
 4. The pond has side slopes of 1:1 and a flat bottom.
- The model was run for three types of 24-hour rainfalls with frequencies of 2, 10, and 25 years. These values were taken from NOAA Atlas 1, Volume 1, and are as follows:

24-HOUR RAINFALL (inches)	24-HOUR RAINFALL (inches)
2.5	2.5
2.4	2.4
1.8	1.8

In this model, Resault was analyzed at two points: Pond 1 and Resault 2. Resault for the site is the existing condition and the capped condition for both Reservoirs 1 and 2. The subcatchment in both the existing condition and capped condition were assumed to cover the same area. At this time, there are no plans that propose changing existing drainage patterns. Within the subcatchment, there were some minor changes made that affected the size of subcatchment area.

Subcatchment 2 - With the existing landfall capped and the area west of the present landfall becoming the active landfall, it was assumed that an access road would cross the south end of this subcatchment and would require a culvert to carry stormwater beneath the road. This

culvert appears as a 24" CMP circular channel in the Tc path for Subcatchment 2 on page 12 of the Hydrocad Report.

Subcatchment 3 - It was assumed that the access road to the future landfill on the west side of the site would cross the south end of Subcatchment 3 and that a culvert would be required to carry stormwater beneath it. This culvert appears as a 30" CMP circular channel in the Tc path for Subcatchment 3 on page 13 of the Hydrocad Report.

Also, in Subcatchments 2, 3, and 4, in the capped condition, it was assumed that most of the area, with the exception of roads and areas designated for storage of recyclables, would be vegetated. The model is conservative in that, in the capped condition, it assumes that the hydrologic condition will be poor (< 50% ground cover) whereas, if properly established and maintained, the condition could be fair or good.

CONCLUSIONS:

Capping the landfill and vegetating the cap and surrounding areas of the site that are not needed for access roads and storage or recyclable processing areas will greatly reduce runoff leaving the site and consequently the potential for erosion. The following table (Table 1: Peak Runoff Flows at Points of Analysis) summarizes the results of this analysis.

TABLE 1: PEAK RUNOFF FLOWS AT POINTS OF ANALYSIS

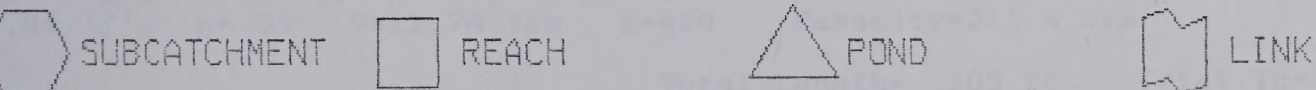
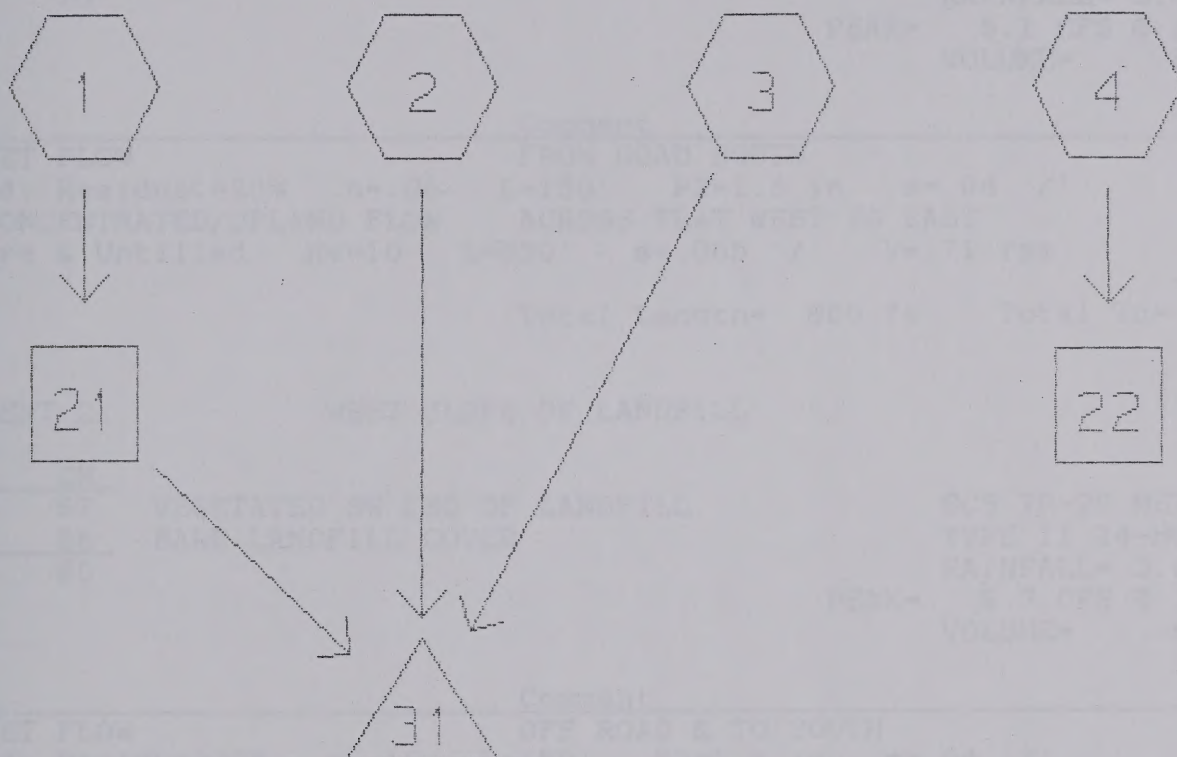
STORM/CONDITION	PEAK STORM RUNOFF (CFS)			
	POND 31		REACH 22	
	AMC I	AMC II	AMC I	AMC II
25 YR/Existing Condition	19.0	37.9	9.4	16.2
25 YR/Capped Condition	4.3	27.3	5.9	13.7
10 YR/Existing Condition	10.3	31.0	4.2	13.3
10 YR/Capped Condition	1.1	20.6	0.9	10.7
2 YR/Existing Condition	0.3	9.0	2.0	6.2
2 YR/Capped Condition	0.0	1.6	0.5	4.3

Based on on-site observations during recent rainfalls and knowledge of the average annual precipitation and evaporation for this area, it appears that the model with Antecedent Moisture Condition I best represents actual conditions. From Table 1, the model indicates

that peak runoff from the existing landfill and the area of the proposed landfill west of it could be reduced by approximately 75% in the 25-year storm, 90% in the 10-year storm, and eliminated entirely in the 2-year event when the landfill is capped and vegetated. Peak runoff from the 8.6-acre area east of the landfill would be reduced approximately 37% in the 25-year storm and approximately 75% in the 10-year and 2-year storms. These peak flow reductions assume that there would be no changes made to the pond or the drainage routing.

Erosion in ditches and swales and at the pond outlet will continue to occur even after the landfill is capped and vegetated unless these areas are stabilized. From the summary sheets and tables on pages 12 through 17 of the Hydrocad Report and pages 21 through 25 attached to the Hydrocad Report, velocities in the ditches and swales exceed 3 feet per second in the 10-year and 25-year storms. Possibly some of these can be stabilized with vegetation, but it is likely riprap or a synthetic erosion control mesh will be needed in the ravine along the southwest side of the landfill, along the access road, and at the pond outlet.

WATERSHED ROUTING



data for MR. M LNDFLL LEWISTOWN, MT EXSTNG CND. SES 93151
 prepared by Applied Microcomputer Systems
 HydroCAD 3.10 000465 (c) 1986-1993 Applied Microcomputer Systems

Page 2
 7 Nov 93

SUBCATCHMENT 1 WEST SIDE OF LANDFILL

ACRES	CN		
3.04	67	VEGETATED	SCS TR-20 METHOD
2.40	86	BARE SOIL	TYPE II 24-HOUR
5.44	75		RAINFALL= 3.0 IN
			PEAK= 5.1 CFS @ 12.12 HRS
			VOLUME= .39 AF

Method	Comment	Tc (min)
R-55 SHEET FLOW	FROM ROAD SOUTH	7.0
Cultivated: Residue<=20% n=.06	L=150' P2=1.6 in s=.04 '/'	
SHALLOW CONCENTRATED/UPLAND FLOW	ACROSS FLAT WEST TO EAST	15.3
Early Bare & Untilled Kv=10	L=650' s=.005 '/' V=.71 fps	
Total Length= 800 ft		Total Tc= 22.3

SUBCATCHMENT 2 WEST SLOPE OF LANDFILL

ACRES	CN		
1.90	67	VEGETATED SW END OF LANDFILL	SCS TR-20 METHOD
4.60	86	BARE LANDFILL COVER	TYPE II 24-HOUR
6.50	80		RAINFALL= 3.0 IN
			PEAK= 8.7 CFS @ 12.09 HRS
			VOLUME= .62 AF

Method	Comment	Tc (min)
R-55 SHEET FLOW	OFF ROAD & TO SOUTH	16.1
Cultivated: Residue>20% n=.17	L=150' P2=1.6 in s=.04 '/'	
SHALLOW CONCENTRATED/UPLAND FLOW	TOE OF SLOPE NW SIDE OF LNDFLL	3.0
Early Bare & Untilled Kv=10	L=475' s=.07 '/' V=2.65 fps	
ECT/VEE/TRAP CHANNEL	TO SW ALONG SBCTCHMNT 1	.2
=5' D=2' SS= .1 & .5 '/' a=34 sq-ft Pw=29.6' r=1.15'		
=.094 '/' n=.03 V=16.67 fps L=170' Capacity=566.7 cfs		
ECT/VEE/TRAP CHANNEL	TO SW ALONG SBCTCHMNT 1	.1
=5' D=2' SS= .5 '/' a=18 sq-ft Pw=13.9' r=1.291'		
=.035 '/' n=.03 V=10.99 fps L=90' Capacity=197.8 cfs		
ECT/VEE/TRAP CHANNEL	TO SW THROUGH RAVINE	.6
=5' D=2' SS= .5 '/' a=18 sq-ft Pw=13.9' r=1.291'		
=.04 '/' n=.03 V=11.74 fps L=420' Capacity=211.4 cfs		
Total Length= 1305 ft		Total Tc= 20.0

Data for MR. M LNDFLL LEWISTOWN, MT EXSTNG CND, SES 93151
Prepared by Applied Microcomputer Systems
HydroCAD 3.10 000465 (c) 1986-1993 Applied Microcomputer Systems

Page 3
7 Nov 93

SUBCATCHMENT 3

EAST FACE OF LANDFILL

ACRES	CN
1.80	67
4.74	86
6.54	81

VEGETATED
BARE LANDFILL COVER

SCS TR-20 METHOD
TYPE II 24-HOUR
RAINFALL= 3.0 IN
PEAK= 10.1 CFS @ 12.04 HRS
VOLUME= .65 AF

Method	Comment	Tc (min)
TR-55 SHEET FLOW	NORTH END, SHEET FLOW TO SE	8.6
Range n=.13 L=100' P2=1.6 in s=.05 '/'		
SHALLOW CONCENTRATED/UPLAND FLOW	ALONG TOE OF SLOPE OF LNDFLL	7.5
Nearly Bare & Untilled Kv=10 L=900' s=.04 '/' V=2 fps		
RECT/VEE/TRAP CHANNEL	SW TOWARD POND	.2
W=5' D=2' SS=.5 '/' a=18 sq-ft Pw=13.9' r=1.291'		
s=.09 '/' n=.013 V=40.66 fps L=450' Capacity=731.8 cfs		
Total Length= 1450 ft		Total Tc= 16.3

SUBCATCHMENT 4

EAST SIDE OF SITE

ACRES	CN
3.20	67
5.46	86
8.66	79

VEGETATED NE QUADRANT OF LNDFLL
BARE LANDFILL COVER & ROADS

SCS TR-20 METHOD
TYPE II 24-HOUR
RAINFALL= 3.0 IN
PEAK= 9.4 CFS @ 12.16 HRS
VOLUME= .78 AF

Method	Comment	Tc (min)
TR-55 SHEET FLOW	NE CORNER, SHEET FLOW TO SOUTH	13.0
Range n=.13 L=150' P2=1.6 in s=.04 '/'		
SHALLOW CONCENTRATED/UPLAND FLOW	SWALE ALONG EDGE OF ACCESS ROAD	12.5
Nearly Bare & Untilled Kv=10 L=1500' s=.04 '/' V=2 fps		
Total Length= 1650 ft		Total Tc= 25.5

EACH 21

RAVINE W. SIDE TO POND

DEPTH (FT)	END AREA (SQ-FT)	DISCH (CFS)
0.0	0.0	0.0
.2	1.1	3.5
.4	2.3	11.2
.6	3.7	22.7
.9	5.8	43.1
1.2	8.9	79.3
1.6	13.1	136.8
2.0	18.0	211.4

5' x 2' CHANNEL
SIDE SLOPE= .5 ' / '
n= .03
LENGTH= 420 FT
SLOPE= .04 FT/FT

STOR-IND METHOD
MAX. DEPTH= .24 FT
PEAK VELOCITY= 3.7 FPS
TRAVEL TIME = 1.9 MIN
Qin = 5.1 CFS @ 12.12 HRS
Qout= 5.0 CFS @ 12.15 HRS
ATTEN= 0 % LAG= 1.3 MIN
IN/OUT= .39 / .39 AF

EACH 22

ROAD DITCH

DEPTH (FT)	END AREA (SQ-FT)	DISCH (CFS)
0.0	0.0	0.0
.2	.8	2.3
.4	1.8	8.0
.6	3.2	17.6
.9	5.5	36.8
1.2	9.4	74.9
1.6	15.0	141.8
2.0	22.0	236.3

3' x 2' CHANNEL
SIDE SLOPE= .25 ' / '
n= .03
LENGTH= 200 FT
SLOPE= .04 FT/FT

STOR-IND METHOD
MAX. DEPTH= .43 FT
PEAK VELOCITY= 4.6 FPS
TRAVEL TIME = .7 MIN
Qin = 9.4 CFS @ 12.16 HRS
Qout= 9.4 CFS @ 12.17 HRS
ATTEN= 0 % LAG= .9 MIN
IN/OUT= .78 / .78 AF

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OND 31

POND AT ENTRANCE TO SITE

STARTING ELEV= 189.0 FT

FLOOD ELEV= 195.0 FT

ELEVATION CUM.STOR

(FT)	(CF)
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15
16	16
17	17
18	18
19	19
20	20
21	21
22	22
23	23
24	24
25	25
26	26
27	27
28	28
29	29
30	30
31	31
32	32
33	33
34	34
35	35
36	36
37	37
38	38
39	39
40	40
41	41
42	42
43	43
44	44
45	45
46	46
47	47
48	48
49	49
50	50
51	51
52	52
53	53
54	54
55	55
56	56
57	57
58	58
59	59
60	60
61	61
62	62
63	63
64	64
65	65
66	66
67	67
68	68
69	69
70	70
71	71
72	72
73	73
74	74
75	75
76	76
77	77
78	78
79	79
80	80
81	81
82	82
83	83
84	84
85	85
86	86
87	87
88	88
89	89
90	90
91	91
92	92
93	93
94	94
95	95
96	96
97	97
98	98
99	99
100	100

189.0 0

192.0 16104

195.0	37488
-------	-------

STOR-IND METHOD

PEAK ELEVATION= 192.7 FT

PEAK STORAGE = 21038 CF

Qin = 23.0 CFS @ 12.08 HRS

Qout = 19.0 CFS @ 12.22 HRS

ATTEN= 17 % LAG= 8.3 MIN

IN/OUT= 1.66 / 1.29 AF

INVERT (FT)

OUTLET DEVICES

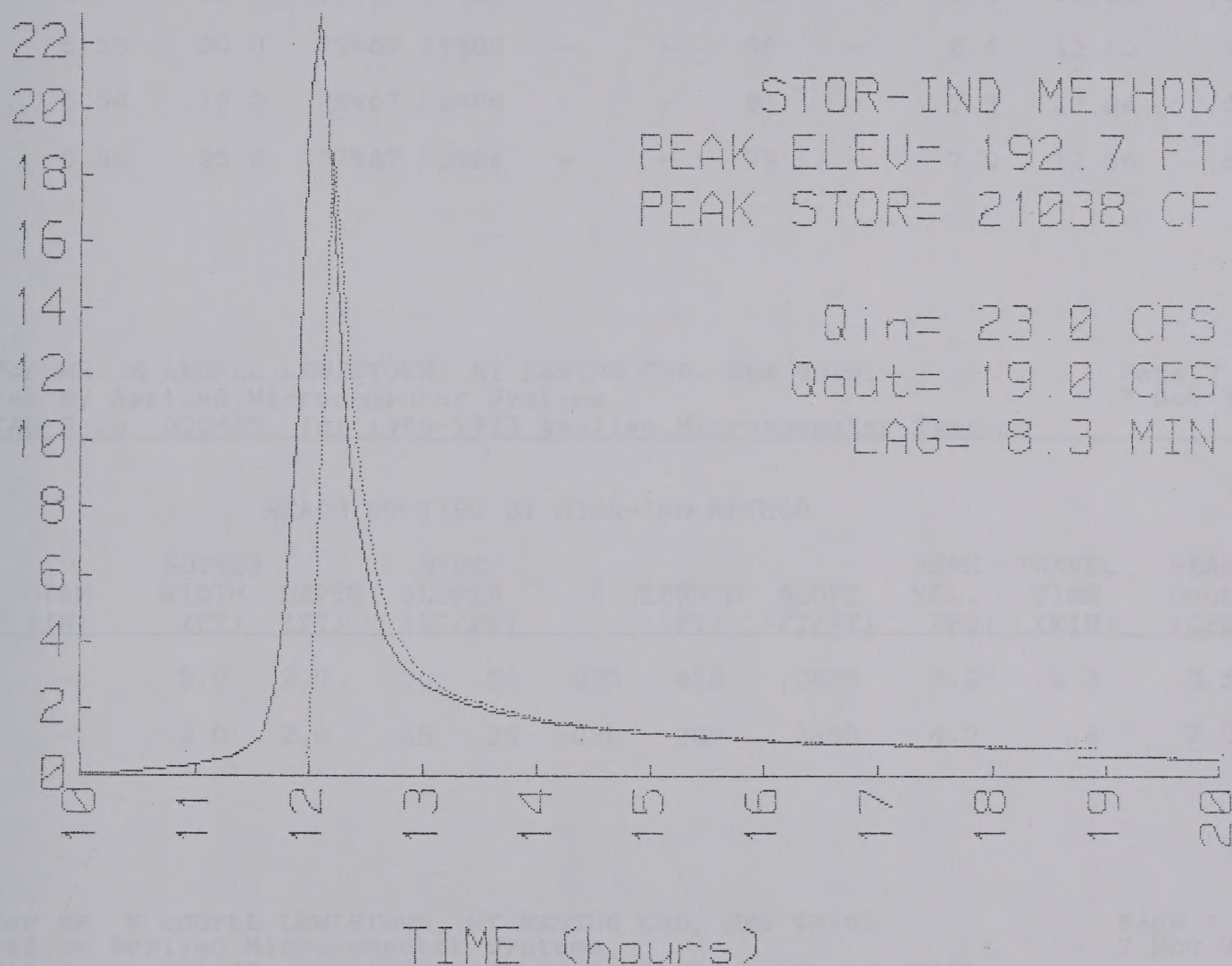
191.9 10' BROAD-CRESTED RECTANGULAR WEIR

Q=C L H^{1.5} C=2.68, 2.62, 0, 0, 0, 0, 0, 0

TOTAL DISCHARGE vs ELEVATION

[illegible]

POND 31 INFLOW & OUTFLOW
POND AT ENTRANCE TO SITE



data for MR. M LNDFLL LEWISTOWN, MT EXSTNG CND, SES 93151
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RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 2.6 IN, SCS U.H.

UBCAT NUMBER	AREA (ACRE)	Tc (MIN)	--GROUND COVERS (%CN)--				WGT'D CN	C	PEAK (CFS)	Tpeak (HRS)	VOL (AF)
1	5.44	22.3	56%67	44%86	-	-	75	-	3.6	12.13	.29
2	6.50	20.0	29%67	71%86	-	-	80	-	6.6	12.10	.47
3	6.54	16.3	28%67	72%86	-	-	81	-	7.7	12.04	.50
4	8.66	25.5	37%67	63%86	-	-	79	-	7.0	12.16	.59

data for MR. M LNDFLL LEWISTOWN, MT EXSTNG CND, SES 93151
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REACH ROUTING BY STOR-IND METHOD

REACH NO.	DIAM (IN)	BOTTOM WIDTH (FT)	DEPTH (FT)	SIDE SLOPES (FT/FT)	n	LENGTH (FT)	SLOPE (FT/FT)	PEAK VEL. (FPS)	TRAVEL TIME (MIN)	PEAK Qout (CFS)
21	-	5.0	2.0	.50 .50	.030	420	.0400	3.2	2.2	3.5
22	-	3.0	2.0	.25 .25	.030	200	.0400	4.2	.8	7.0

data for MR. M LNDFLL LEWISTOWN, MT EXSTNG CND, SES 93151
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POND ROUTING BY STOR-IND METHOD

POND NO.	OUTLET DEVICES	START ELEV. (FT)	FLOOD ELEV. (FT)	PEAK ELEV. (FT)	PEAK STORAGE (AF)	---PEAK FLOW---		ATTEN. (%)	LAG (MIN)
						Qin (CFS)	Qout (CFS)		
31	1	189.0	195.0	192.4	.44	17.0	10.3	39	13.6

ata for MR. M LND FLL LEWISTOWN, MT EXSTNG CND, SES 93151
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RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 1.6 IN, SCS U.H.

UBCAT UMBER	AREA (ACRE)	Tc (MIN)	--GROUND COVERS (%CN)--				WGT'D CN		PEAK (CFS)	Tpeak (HRS)	VOL (AF)
1	5.44	22.3	56%67	44%86	-	-	75	-	.7	12.18	.08
2	6.50	20.0	29%67	71%86	-	-	80	-	2.0	12.12	.16
3	6.54	16.3	28%67	72%86	-	-	81	-	2.5	12.07	.18
4	8.66	25.5	37%67	63%86	-	-	79	-	2.0	12.20	.19

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REACH ROUTING BY STOR-IND METHOD

REACH NO.	DIAM (IN)	BOTTOM WIDTH (FT)	DEPTH (FT)	SIDE SLOPES (FT/FT)	n	LENGTH (FT)	SLOPE (FT/FT)	PEAK VEL. (FPS)	TRAVEL TIME (MIN)	PEAK Qout (CFS)
21	-	5.0	2.0	.50 .50	.030	420	.0400	3.2	2.2	.7
22	-	3.0	2.0	.25 .25	.030	200	.0400	3.0	1.1	2.0

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POND ROUTING BY STOR-IND METHOD

POND NO.	OUTLET DEVICES	START ELEV. (FT)	FLOOD ELEV. (FT)	PEAK ELEV. (FT)	PEAK STORAGE (AF)	---PEAK FLOW---		ATTEN. (%)	LAG (MIN)
						Qin (CFS)	Qout (CFS)		
31	1	189.0	195.0	191.9	.36	4.9	3.3	95	339.7

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RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 3.0 IN, SCS U.H.

UBCAT NUMBER	AREA (ACRE)	Tc (MIN)	---GROUND COVERS (%CN)---				WGT'D CN	C	PEAK (CFS)	Tpeak (HRS)	VOL (AF)
1	5.44	22.3	56%83	44%94	-	-	88	-	10.2	12.11	.75
2	6.50	20.0	29%83	71%94	-	-	91	-	14.4	12.08	1.00
3	6.54	16.3	28%83	72%94	-	-	91	-	16.0	12.03	1.01
4	8.66	25.5	37%83	63%94	-	-	90	-	16.2	12.14	1.29

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REACH ROUTING BY STOR-IND METHOD

REACH NO.	DIAM (IN)	BOTTOM WIDTH (FT)	DEPTH (FT)	SIDE SLOPES (FT/FT)	n	LENGTH (FT)	SLOPE (FT/FT)	PEAK VEL. (FPS)	TRAVEL TIME (MIN)	PEAK Qout (CFS)
21	-	5.0	2.0	.50 .50	.030	420	.0400	4.7	1.5	10.0
22	-	3.0	2.0	.25 .25	.030	200	.0400	5.3	.6	16.2

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POND ROUTING BY STOR-IND METHOD

POND NO.	OUTLET DEVICES	START ELEV. (FT)	FLOOD ELEV. (FT)	PEAK ELEV. (FT)	PEAK STORAGE (AF)	---PEAK FLOW---		ATTEN. (%)	LAG (MIN)
						Qin (CFS)	Qout (CFS)		
31	1	189.0	195.0	193.2	.56	39.0	37.9	3	3.1

10 YR STORM

Data for MR. M LNDFLL, MT, EXSTG CND, AMC II, SES 93151

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RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 2.6 IN, SCS U.H.

JBCAT NUMBER	AREA (ACRE)	Tc (MIN)	--GROUND COVERS (%CN)--				WGT'D CN	C	PEAK (CFS)	Tpeak (HRS)	VOL (AF)
1	5.44	22.3	56%83	44%94	-	-	88	-	8.2	12.11	.61
2	6.50	20.0	29%83	71%94	-	-	91	-	11.9	12.08	.83
3	6.54	16.3	28%83	72%94	-	-	91	-	13.2	12.03	.84
4	8.66	25.5	37%83	63%94	-	-	90	-	13.3	12.14	1.06

Data for MR. M LNDFLL, MT, EXSTG CND, AMC II, SES 93151

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REACH ROUTING BY STOR-IND METHOD

REACH NO.	DIAM (IN)	BOTTOM WIDTH (FT)	DEPTH (FT)	SIDE SLOPES (FT/FT)	n	LENGTH (FT)	SLOPE (FT/FT)	PEAK VEL. (FPS)	TRAVEL TIME (MIN)	PEAK Qout (CFS)
21	-	5.0	2.0	.50 .50	.030	420	.0400	4.4	1.6	8.1
22	-	3.0	2.0	.25 .25	.030	200	.0400	5.1	.7	13.3

Data for MR. M LNDFLL, MT, EXSTG CND, AMC II, SES 93151

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POND ROUTING BY STOR-IND METHOD

OND NO.	OUTLET DEVICES	START ELEV. (FT)	FLOOD ELEV. (FT)	PEAK ELEV. (FT)	PEAK STORAGE (AF)	---PEAK FLOW---				ATTEN. (%)	LAG (MIN)
						Qin (CFS)	Qout (CFS)				
31	1	189.0	195.0	193.0	.53	32.1	31.0			3	3.6

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RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 1.6 IN, SCS U.H.

UBCAT UMBER	AREA (ACRE)	Tc (MIN)	--GROUND COVERS (%CN)--				WGT'D CN	C	PEAK (CFS)	Tpeak (HRS)	VOL (AF)
1	5.44	22.3	56%83	44%94	-	-	88	-	3.6	12.12	.27
2	6.50	20.0	29%83	71%94	-	-	91	-	5.8	12.09	.41
3	6.54	16.3	28%83	72%94	-	-	91	-	6.4	12.04	.41
4	8.66	25.5	37%83	63%94	-	-	90	-	6.2	12.15	.50

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REACH ROUTING BY STOR-IND METHOD

REACH NO.	DIAM (IN)	BOTTOM WIDTH (FT)	DEPTH (FT)	SIDE SLOPES (FT/FT)	n	LENGTH (FT)	SLOPE (FT/FT)	PEAK VEL. (FPS)	TRAVEL TIME (MIN)	PEAK Qout (CFS)
21	-	5.0	2.0	.50 .50	.030	420	.0400	3.2	2.2	3.4
22	-	3.0	2.0	.25 .25	.030	200	.0400	4.1	.8	6.2

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POND ROUTING BY STOR-IND METHOD

POND NO.	OUTLET DEVICES	START ELEV. (FT)	FLOOD ELEV. (FT)	PEAK ELEV. (FT)	PEAK STORAGE (AF)	---PEAK FLOW---		ATTEN. (%)	LAG (MIN)
						Qin (CFS)	Qout (CFS)		
31	1	189.0	195.0	192.4	.43	15.0	9.0	40	13.3

Data for MR. M LND FLL, MT, CAPPED CND, AMC I, SES 93151Page 12
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SUBCATCHMENT 1

FUTURE LANDFILL, WEST SIDE OF SITE

ACRES	CN
3.04	67
2.40	86
5.44	75

VEGETATED
BARE SOIL

SCS TR-20 METHOD

TYPE II 24-HOUR

RAINFALL= 3.0 IN

PEAK= 5.1 CFS @ 12.12 HRS

VOLUME= .39 AF

Method	Comment	Tc (min)
R-55 SHEET FLOW	FROM ROAD SOUTH	7.0
Cultivated: Residue<=20% n=.06	L=150' P2=1.6 in s=.04 '/'	
HALLOW CONCENTRATED/UPLAND FLOW	ACROSS FLAT WEST TO EAST	15.3
Early Bare & Untilled Kv=10	L=650' s=.005 '/' V=.71 fps	
Total Length= 800 ft		Total Tc= 22.3

SUBCATCHMENT 2

WEST SLOPE OF EXISTING LANDFILL

ACRES	CN
5.50	67
1.00	86
6.50	70

VEGETATED SW END OF LANDFILL
ACCESS ROAD & RECYCLABLES AREA

SCS TR-20 METHOD

TYPE II 24-HOUR

RAINFALL= 3.0 IN

PEAK= 4.4 CFS @ 12.11 HRS

VOLUME= .34 AF

Method	Comment	Tc (min)
R-55 SHEET FLOW	OFF ROAD & TO SOUTH	16.1
Cultivated: Residue>20% n=.17	L=150' P2=1.6 in s=.04 '/'	
HALLOW CONCENTRATED/UPLAND FLOW	TOE OF SLOPE NW SIDE OF LND FLL	3.0
Early Bare & Untilled Kv=10	L=475' s=.07 '/' V=2.65 fps	
RECT/VEE/TRAP CHANNEL	TO SW ALONG SUBCATCHMENT 1	.2
5' D=2' SS=.1 & .5 '/'	a=34 sq-ft Pw=29.6' r=1.15'	
.094 '/'	n=.03 V=16.67 fps L=170' Capacity=566.7 cfs	
CIRCULAR CHANNEL	FUTURE CULVERT ACROSS ACCESS RD	.2
4" Diameter a=3.14 sq-ft	Pw=6.3' r=.5'	
.035 '/'	n=.025 V=7.01 fps L=90' Capacity=22 cfs	
RECT/VEE/TRAP CHANNEL	TO SW THROUGH RAVINE	.6
5' D=2' SS=.5 '/'	a=18 sq-ft Pw=13.9' r=1.291'	
.04 '/'	n=.03 V=11.74 fps L=420' Capacity=211.4 cfs	
Total Length= 1305 ft		Total Tc= 20.1

Data for MR. M LND FLL, MT, CAPPED CND, AMC I, SES 93151

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SUBCATCHMENT 3

EAST FACE OF EXISTING LANDFILL

ACRES	CN
5.30	67
.24	86
5.54	68

VEGETATED

ACCESS ROAD TO WEST SIDE OF SITE

SCS TR-20 METHOD

TYPE II 24-HOUR

RAINFALL= 3.0 IN

PEAK= 3.4 CFS @ 12.08 HRS

VOLUME= .25 AF

Method	Comment	Tc (min)
R-55 SHEET FLOW	NORTH END, SHEET FLOW TO SE	8.6
Range n=.13 L=100' P2=1.6 in s=.05 '/'		
HALLOW CONCENTRATED/UPLAND FLOW	ALONG TOE OF SLOPE OF LND FLL	7.5
Early Bare & Untilled Kv=10 L=900' s=.04 '/'	V=2 fps	
RECT/VEE/TRAP CHANNEL	SW TOWARD POND	.2
=5' D=2' SS=.5 '/'	a=18 sq-ft Pw=13.9' r=1.291'	
=.09 '/'	n=.03 V=17.62 fps L=175' Capacity=317.1 cfs	
CIRCULAR CHANNEL	FUTURE CULVERT ACROSS ACCESS RD	.1
0" Diameter a=4.91 sq-ft Pw=7.9' r=.625'		
=.09 '/'	n=.025 V=13.04 fps L=75' Capacity=64 cfs	
RECT/VEE/TRAP CHANNEL	DITCH TO POND	.2
=5' D=2' SS=.5 '/'	a=18 sq-ft Pw=13.9' r=1.291'	
=.09 '/'	n=.03 V=17.62 fps L=200' Capacity=317.1 cfs	

Total Length= 1450 ft Total Tc= 16.6

SUBCATCHMENT 4

EAST SIDE OF SITE

ACRES	CN
6.20	67
2.46	86
8.66	72

VEGETATED NE QUADRANT OF LND FLL

ROADS & MISCELLANEOUS STORAGE

SCS TR-20 METHOD

TYPE II 24-HOUR

RAINFALL= 3.0 IN

PEAK= 5.9 CFS @ 12.18 HRS

VOLUME= .52 AF

Method	Comment	Tc (min)
R-55 SHEET FLOW	NE CORNER, SHEET FLOW TO SOUTH	13.0
Range n=.13 L=150' P2=1.6 in s=.04 '/'		
HALLOW CONCENTRATED/UPLAND FLOW	SWALE ALONG EDGE OF ACCESS ROAD	12.5
Early Bare & Untilled Kv=10 L=1500' s=.04 '/'	V=2 fps	
Total Length= 1650 ft Total Tc= 25.5		

Data for MR. M LND FLL, MT, CAPPED CND, AMC I, SES 93151

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REACH 21

RAVINE W. SIDE TO POND

DEPTH (FT)	END AREA (SQ-FT)	DISCH (CFS)
0.0	0.0	0.0
.2	1.1	3.5
.4	2.3	11.2
.6	3.7	22.7
.9	5.8	43.1
1.2	8.9	79.3
1.6	13.1	136.8
2.0	18.0	211.4

5' x 2' CHANNEL
 SIDE SLOPE= .5'/'
 n= .03
 LENGTH= 420 FT
 SLOPE= .04 FT/FT

STOR-IND METHOD

MAX. DEPTH= .24 FT
 PEAK VELOCITY= 3.7 FPS
 TRAVEL TIME = 1.9 MIN
 Qin = 5.1 CFS @ 12.12 HRS
 Qout= 5.0 CFS @ 12.15 HRS
 ATTEN= 0 % LAG= 1.3 MIN
 IN/OUT= .39 / .39 AF

REACH 22

ROAD DITCH

DEPTH (FT)	END AREA (SQ-FT)	DISCH (CFS)
0.0	0.0	0.0
.2	.8	2.3
.4	1.8	8.0
.6	3.2	17.6
.9	5.5	36.8
1.2	9.4	74.9
1.6	15.0	141.8
2.0	22.0	236.3

3' x 2' CHANNEL
 SIDE SLOPE= .25'/'
 n= .03
 LENGTH= 200 FT
 SLOPE= .04 FT/FT

STOR-IND METHOD

MAX. DEPTH= .33 FT
 PEAK VELOCITY= 4.1 FPS
 TRAVEL TIME = .8 MIN
 Qin = 5.9 CFS @ 12.18 HRS
 Qout= 5.9 CFS @ 12.19 HRS
 ATTEN= 0 % LAG= .6 MIN
 IN/OUT= .52 / .52 AF

Data for MR. M LND FLL, MT, CAPPED CND, AMC I, SES 93151

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RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 2.6 IN, SCS U.H.

IBCAT NUMBER	AREA (ACRE)	Tc (MIN)	--GROUND COVERS (%CN)--				WGT'D CN C		PEAK (CFS)	Tpeak (HRS)	VOL (AF)
1	5.44	22.3	56%67	44%86	-	-	75	-	3.6	12.13	.29
2	6.50	20.1	85%67	15%86	-	-	70	-	2.9	12.12	.24
3	5.54	16.8	96%67	4%86	-	-	68	-	2.1	12.09	.17
4	8.66	25.5	72%67	28%86	-	-	72	-	4.0	12.19	.37

Data for MR. M LND FLL, MT, CAPPED CND, AMC I, SES 93151

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REACH ROUTING BY STOR-IND METHOD

REACH NO.	DIAM (IN)	BOTTOM WIDTH (FT)	DEPTH (FT)	SIDE SLOPES (FT/FT)		n	LENGTH (FT)	SLOPE (FT/FT)	PEAK VEL. (FPS)	TRAVEL TIME (MIN)	PEAK Qout (CFS)
21	-	5.0	2.0	.50	.50	.030	420	.0400	3.2	2.2	3.5
22	-	3.0	2.0	.25	.25	.030	200	.0400	3.7	.9	4.0

Data for MR. M LND FLL, MT, CAPPED CND, AMC I, SES 93151

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POND ROUTING BY STOR-IND METHOD

INLET NO.	OUTLET DEVICES	START ELEV. (FT)	FLOOD ELEV. (FT)	PEAK ELEV. (FT)	PEAK STORAGE (AF)	---PEAK FLOW---		ATTEN. (%)	LAG (MIN)
						Qin (CFS)	Qout (CFS)		
31	1	189.0	195.0	192.0	.37	8.3	1.1	86	71.4

Data for MR. M LND FLL, MT, CAPPED CND, AMC I, SES 93151
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RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 1.6 IN, SCS U.H.

SUBCAT NUMBER	AREA (ACRE)	Tc (MIN)	---GROUND COVERS (%CN)---				WGT'D CN	C	PEAK (CFS)	Tpeak (HRS)	VOL (AF)
1	5.44	22.3	56%67	44%86	-	-	75	-	.7	12.18	.08
2	6.50	20.1	85%67	15%86	-	-	70	-	.2	12.22	.05
3	5.54	16.8	96%67	4%86	-	-	68	-	.1	12.26	.03
4	8.66	25.5	72%67	28%86	-	-	72	-	.5	12.26	.09

Data for MR. M LND FLL, MT, CAPPED CND, AMC I, SES 93151
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REACH ROUTING BY STOR-IND METHOD

REACH NO.	DIAM (IN)	BOTTOM WIDTH (FT)	DEPTH (FT)	SIDE SLOPES (FT/FT)		n	LENGTH (FT)	SLOPE (FT/FT)	PEAK VEL. (FPS)	TRAVEL TIME (MIN)	PEAK Qout (CFS)
21	-	5.0	2.0	.50	.50	.030	420	.0400	3.2	2.2	.7
22	-	3.0	2.0	.25	.25	.030	200	.0400	3.0	1.1	.5

Data for MR. M LND FLL, MT, CAPPED CND, AMC I, SES 93151
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POND ROUTING BY STOR-IND METHOD

POND NO.	OUTLET DEVICES	START ELEV. (FT)	FLOOD ELEV. (FT)	PEAK ELEV. (FT)	PEAK STORAGE (AF)	---PEAK FLOW---		ATTEN. (%)	LAG (MIN)
						Qin (CFS)	Qout (CFS)		
31	1	189.0	195.0	190.3	.16	1.0	0.0	100	0.0

Capped

Data for MR. M LND FLL, MT, ~~EXSTG~~ CND, AMC II, SES 93151

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RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 3.0 IN, SCS U.H.

SUBCAT NUMBER	AREA (ACRE)	Tc (MIN)	---GROUND COVERS (%CN)---				WGT'D CN C		PEAK (CFS)	Tpeak (HRS)	VOL (AF)
1	5.44	22.3	56%83	44%94	-	-	88	-	10.2	12.11	.75
2	6.50	20.1	85%83	15%94	-	-	85	-	11.2	12.09	.78
3	5.54	16.6	96%83	4%94	-	-	83	-	9.4	12.04	.61
4	8.66	25.5	72%83	28%94	-	-	86	-	13.6	12.14	1.09

Capped

Data for MR. M LND FLL, MT, ~~EXSTG~~ CND, AMC II, SES 93151

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REACH ROUTING BY STOR-IND METHOD

REACH NO.	DIAM (IN)	BOTTOM WIDTH (FT)	DEPTH (FT)	SIDE SLOPES (FT/FT)		n	LENGTH (FT)	SLOPE (FT/FT)	PEAK VEL. (FPS)	TRAVEL TIME (MIN)	PEAK Qout (CFS)
21	-	5.0	2.0	.50	.50	.030	420	.0400	4.7	1.5	10.0
22	-	3.0	2.0	.25	.25	.030	200	.0400	5.1	.7	13.7

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POND ROUTING BY STOR-IND METHOD

POND NO.	OUTLET DEVICES	START ELEV. (FT)	FLOOD ELEV. (FT)	PEAK ELEV. (FT)	PEAK STORAGE (AF)	---PEAK FLOW---		ATTEN. (%)	LAG (MIN)
						Qin (CFS)	Qout (CFS)		
31	1	189.0	195.0	192.9	.52	29.9	27.3	9	4.3

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RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 2.6 IN, SCS U.H.

UBCAT NUMBER	AREA (ACRE)	Tc (MIN)	--GROUND COVERS (%CN)--				WGT'D CN	C	PEAK (CFS)	Tpeak (HRS)	VOL (AF)
1	5.44	22.3	56%83	44%94	-	-	88	-	8.2	12.11	.61
2	6.50	20.1	85%83	15%94	-	-	85	-	8.8	12.09	.62
3	5.54	16.6	96%83	4%94	-	-	83	-	7.3	12.04	.48
4	8.66	25.5	72%83	28%94	-	-	86	-	10.8	12.15	.87

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REACH ROUTING BY STOR-IND METHOD

REACH NO.	DIAM (IN)	BOTTOM WIDTH (FT)	DEPTH (FT)	SIDE SLOPES (FT/FT)	n	LENGTH (FT)	SLOPE (FT/FT)	PEAK VEL. (FPS)	TRAVEL TIME (MIN)	PEAK Gout (CFS)
21	-	5.0	2.0	.50 .50	.030	420	.0400	4.4	1.6	8.1
22	-	3.0	2.0	.25 .25	.030	200	.0400	4.8	.7	10.7

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POND ROUTING BY STOR-IND METHOD

POND NO.	OUTLET DEVICES	START ELEV. (FT)	FLOOD ELEV. (FT)	PEAK ELEV. (FT)	PEAK STORAGE (AF)	---PEAK FLOW---		ATTEN. (%)	LAG (MIN)
						Qin (CFS)	Qout (CFS)		
31	1	189.0	195.0	192.7	.49	23.7	20.6	13	7.2

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RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 1.6 IN, SCS U.H.

UBCAT NUMBER	AREA (ACRE)	Tc (MIN)	--GROUND COVERS (%CN)--				WGT'D CN	C	PEAK (CFS)	Tpeak (HRS)	VOL (AF)
1	5.44	22.3	56%83	44%94	-	-	88	-	3.6	12.12	.27
2	6.50	20.1	85%83	15%94	-	-	85	-	3.5	12.10	.25
3	5.54	16.6	96%83	4%94	-	-	83	-	2.6	12.06	.18
4	8.66	25.5	72%83	28%94	-	-	86	-	4.3	12.16	.36

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REACH ROUTING BY STOR-IND METHOD

REACH NO.	DIAM (IN)	BOTTOM WIDTH (FT)	DEPTH (FT)	SIDE SLOPES (FT/FT)	n	LENGTH (FT)	SLOPE (FT/FT)	PEAK VEL. (FPS)	TRAVEL TIME (MIN)	PEAK Qout (CFS)
21	-	5.0	2.0	.50 .50	.030	420	.0400	3.2	2.2	3.4
22	-	3.0	2.0	.25 .25	.030	200	.0400	3.8	.9	4.3

Capped

ata for MR. M LND FLL, MT, ~~EXSTG~~ CND, AMC II, SES 93151
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POND ROUTING BY STOR-IND METHOD

POND NO.	OUTLET DEVICES	START ELEV. (FT)	FLOOD ELEV. (FT)	PEAK ELEV. (FT)	PEAK STORAGE (AF)	---PEAK FLOW---		ATTEN. (%)	LAG (MIN)
						Qin (CFS)	Qout (CFS)		
31	1	189.0	195.0	192.0	.38	9.3	1.6	83	42.7

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Mr. M Landfill

Comment: DITCH ALONG LNDFLL TOE TO SW BY SBCTCHMNT 1

Solve For Depth

Given Input Data:

Bottom Width.....	5.00 ft
Left Side Slope..	10.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0940 ft/ft
Discharge.....	4.40 cfs

← from page 12
Subcatchment 2

Computed Results:

Depth.....	0.17 ft
Velocity.....	4.22 fps
Flow Area.....	1.04 sf
Flow Top Width...	7.07 ft
Wetted Perimeter.	7.12 ft
Critical Depth...	0.26 ft
Critical Slope...	0.0224 ft/ft
Froude Number....	1.94 (flow is Supercritical)

← > 3 fps likely to get scour

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Mr. M Landfill

Comment: DITCH ALONG LNDFLL TOE TO SW BY SBCTCHMNT 1

Solve For Depth

Given Input Data:

Bottom Width.....	5.00 ft
Left Side Slope..	10.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0940 ft/ft
Discharge.....	2.90 cfs

← from page 16
Subcatchment 2

Computed Results:

Depth.....	0.14 ft
Velocity.....	3.67 fps
Flow Area.....	0.79 sf
Flow Top Width...	6.63 ft
Wetted Perimeter.	6.67 ft
Critical Depth...	0.20 ft
Critical Slope...	0.0240 ft/ft
Froude Number....	1.87 (flow is Supercritical)

← > 3 fps

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Mr. M Landfill

Comment: DITCH ALONG LNDFLL TOE TO SW BY SBCTCHMNT 1

Solve For Depth

Given Input Data:

Bottom Width.....	5.00 ft
Left Side Slope..	10.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0940 ft/ft
Discharge.....	0.20 cfs

← from page 17
Subcatchment 2

Computed Results:

Depth.....	0.03 ft
Velocity.....	1.37 fps
Flow Area.....	0.15 sf
Flow Top Width...	5.34 ft
Wetted Perimeter.	5.35 ft
Critical Depth...	0.04 ft
Critical Slope...	0.0403 ft/ft
Froude Number....	1.47 (flow is Supercritical)

← ok

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Mr. M Landfill

Comment: DITCH ALONG EAST ACCESS RD.

Solve For Depth

Given Input Data:

Bottom Width.....	5.00 ft
Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0900 ft/ft
Discharge.....	3.40 cfs

← from page 13
Subcatchment 3

Computed Results:

Depth.....	0.16 ft
Velocity.....	4.11 fps
Flow Area.....	0.83 sf
Flow Top Width...	5.62 ft
Wetted Perimeter.	5.70 ft
Critical Depth...	0.24 ft
Critical Slope...	0.0224 ft/ft
Froude Number....	1.89 (flow is Supercritical)

← > 3 fps scour likely

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Mr. M Landfill

Comment: DITCH ALONG EAST ACCESS RD.

Solve For Depth

Given Input Data:

Bottom Width.....	5.00 ft
Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0900 ft/ft
Discharge.....	2.10 cfs

← from page 16
Subcatchment 3

Computed Results:

Depth.....	0.12 ft
Velocity.....	3.43 fps
Flow Area.....	0.61 sf
Flow Top Width...	5.47 ft
Wetted Perimeter.	5.52 ft
Critical Depth...	0.17 ft
Critical Slope...	0.0245 ft/ft
Froude Number....	1.81 (flow is Supercritical)

← > 3 Scar likely

Table 2-2b.—Runoff curve numbers for cultivated agricultural lands¹

Cover description			Curve numbers for hydrologic soil group—				
Cover type	Treatment ²	Hydrologic condition ³	A	B	C	D	
Fallow	Bare soil	—	77	86	91	94	
	Crop residue cover (CR)	Poor	76	85	90	93	Pasture, grass forage for
		Good	74	83	88	90	
Row crops	Straight row (SR)	Poor	72	81	88	91	Meadow—cor grazing an
		Good	67	78	85	89	
	SR + CR	Poor	71	80	87	90	Brush—brus the major
		Good	64	75	82	85	
	Contoured (C)	Poor	70	79	84	88	Woods—gra or tree fa
		Good	65	75	82	86	
	C + CR	Poor	69	78	83	87	Woods ⁴
		Good	64	74	81	85	
	Contoured & terraced (C&T)	Poor	66	74	80	82	
		Good	62	71	78	81	
Small grain	SR	Poor	65	76	84	88	Farmstead and surr
		Good	63	75	83	87	
	SR + CR	Poor	64	75	83	86	Average r
		Good	60	72	80	84	
	C	Poor	63	74	82	85	*Poor: < 50 Fair: 50 Good: >
		Good	61	73	81	84	
	C + CR	Poor	62	73	81	84	*Poor: < 50 Fair: 50 Good: >
		Good	60	72	80	83	
	C&T	Poor	61	72	79	82	*Actual cu
		Good	59	70	78	81	
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89	*CN's sho from the C
		Good	58	72	81	85	
	C	Poor	64	75	83	85	*Poor: F Fair: V Good: V
		Good	55	69	78	83	
	C&T	Poor	63	73	80	83	
		Good	51	67	76	80	

¹Average runoff condition, and $I_a = 0.25$.²Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.³Hydrologic condition is based on combination of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes in rotations, (d) percent of residue cover on the land surface (good $\geq 20\%$), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 2-2c.—Runoff curve numbers for other agricultural lands¹

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. ²	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. ³	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30	48	65	73
Woods—grass combination (orchard or tree farm). ⁵	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods ⁶	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

¹Average runoff condition, and $I_a = 0.2S$.

²*Poor*: <50% ground cover or heavily grazed with no mulch.

Fair: 50 to 75% ground cover and not heavily grazed.

Good: >75% ground cover and lightly or only occasionally grazed.

³*Poor*: <50% ground cover.

Fair: 50 to 75% ground cover.

Good: >75% ground cover.

⁴Actual curve number is less than 30; use CN = 30 for runoff computations.

⁵CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

⁶*Poor*: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.

Fair: Woods are grazed but not burned, and some forest litter covers the soil.

Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

← Normally used

Antecedent Soil Moisture Condition

28

Antecedent soil moisture is known to have a significant effect on both the volume and rate of runoff. Recognizing that it is a significant factor, SCS developed three antecedent soil moisture conditions, which were labeled I, II, and III. The soil condition for each is as follows:

Condition I: soils are dry but not to wilting point;
satisfactory cultivation has taken place.

Condition II: average conditions

Condition III: heavy rainfall, or light rainfall and low
temperatures have occurred within the last
5 days; saturated soil.

The following table gives seasonal rainfall limits for the three antecedent soil moisture conditions:

AMC	Total 5-day Antecedent Rainfall (inches)	
	<u>Dormant Season</u>	<u>Growing Season</u>
I	Less than 0.5	Less than 1.4
II	0.5 to 1.1	1.4 to 2.1
III	over 1.1	over 2.1

In design, the antecedent soil moisture condition is often a policy decision rather than a statement of actual soil conditions at the site during development.

The CN values obtained from Table 2 are for soil moisture condition II. If either soil condition I or III is to be used, the CN can be adjusted using the following table:

CN for Condition II	Corresponding CN for Condition	
	I	III
100	100	100
95	87	99
90	78	98
85	70	97
80	63	94
75	57	91
70	51	87
65	45	83
60	40	79
55	35	75
50	31	70
45	27	65
40	23	60
35	19	55
30	15	50
25	12	45
20	9	39
15	7	33
10	4	26
5	2	17
0	0	0

Mister M

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t :

$$T_t = \frac{0.007 (nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \quad [\text{Eq. 3-3}]$$

↑ 3.4 IN STORM

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n^1
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover $\leq 20\%$	0.06
Residue cover $> 20\%$	0.17
Grass:	
Short grass prairie	0.15
Dense grasses ²	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods: ³	
Light underbrush	0.40
Dense underbrush	0.80

¹The n values are a composite of information compiled by Engman (1986).

²Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

³When selecting n , consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

where

T_t = travel time (hr),

n = Manning's roughness coefficient (table 3-1),

L = flow length (ft),

P_2 = 2-year, 24-hour rainfall (in), and

s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

